

The Influence of Organizational Hierarchy and Departmental Structure on
Communication: The Case of Kaplan and Norton's Balanced Scorecard in a
Matrix Organization.

By
James Clayton Kopp

Submitted to the System Design and Management Program
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Engineering and Management

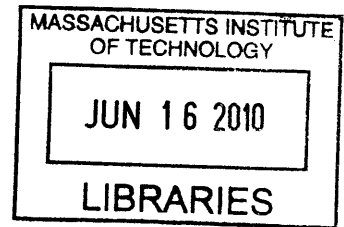
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Signature of Author _____

Handwritten signature of James Clayton Kopp in black ink.

James Clayton Kopp
System Design and Management Program
2008 Cohort

Certified by _____

Handwritten signature of Christopher L. Magee in black ink.

Christopher L. Magee
Faculty Thesis Advisor

Certified by _____

Handwritten signature of Robert Slack in black ink.

Robert Slack
Corporate Thesis Advisor
Engineering Director, Hamilton Sundstrand

Certified by _____

Handwritten signature of Patrick Hale in black ink.

Patrick Hale
Director, System Design and Management Program

DEDICATION

For my wife, the strongest and wisest person I know; and for my daughters, who are ready to have their Dad back.

BRIEF BIOGRAPHICAL NOTE

The author of this thesis, Clayton Kopp, is a 2010 M.S. candidate for graduation from the MIT System Design and Management Program. He obtained his BS in Mechanical Engineering from Georgia Tech in 1993 and an MS in Mechanical Engineering from Clemson University in 1998.

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ABSTRACT

A large business requires efficient and effective internal communication among employees to achieve its goals. Dodds, Watts, and Sable (DWS) introduced a communication network model assessing information flow within a business by examining the relative influences of organizational structure, message volatility, and task decomposability on the probability of successful message transmission, but there is no research available that examines this or similar models in the context of a real business. The model predicts optimal message flow in a "Multi-scale" organizational network, a structure which in practice may most resemble a matrix organization. In this study a survey was designed to measure the influence of rank and department on message transfer – particularly the informational attributes of understanding, accuracy, importance, and influenceability – originating from the Balanced Scorecard in a large, matrix-managed aerospace business. The survey data indicated the following results:

- Understanding (of the Balanced Scorecard metrics) was significantly influenced by employee rank and exhibited some effects of departmental expertise with certain metrics.
- Belief in the accuracy of the metrics correlated highly with Understanding.
- Importance rankings of the metric displayed high alignment across both rank and department, an encouraging result for company management.
- Influenceability (people's belief they could affect the metric) was heavily influenced by rank and somewhat influenced by department. It also generally exhibited the lowest levels and highest variation when compared to the other attributes.
- A deeper analysis comparing the Engineering and Program Office departments revealed consistently better vertical communication for Engineering, and better lateral communication within ranks for Program Office, which may indicate an additional influence of department culture on information flow.

When subjected to a DWS interpretation, the survey results provided clues about relative influences of rank and department on message flow and relative values of other DWS model parameters – task decomposability and message traffic volume – could be gleaned from employee comments and post-survey interviews. The study falls short of making absolute characterizations of the DWS attributes, but is able to make inferences regarding the communication of the separate attributes relative to each other. Indeed, one important implication of the work done here to DWS theory is that for different business concerns and for different organizations within the overall company, there are apparently different mappings onto the DWS communication framework. Analysis of the study data for this organization indicates lateral communication may be better than vertical communication for Understanding and Influenceability; Accuracy does not exhibit dominance by either parameter; and Importance is well communicated laterally and vertically. More empirical data on measurable information traffic such as email is needed from different organizations, industries, and national cultures for DWS parameter values to converge upon more absolute values.

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1 INTRODUCTION

A large business requires efficient and effective internal communication among employees to achieve its goals. The more effective the communication, the greater the probability that the intended message is received, is correctly interpreted, and initiates the appropriate action; the more efficient the communication, the less resources the message consumes in its effective transmission. This communication takes on a variety of forms – formal and informal; written and spoken; remote and face-to-face; quantitative and qualitative; verbal and symbolic – each form varying in efficiency and effectiveness, often trading the benefits of one form for the other depending on the context and content.

The medium of the message has a significant influence on both efficiency and effectiveness. For instance, a telephone call is usually more effective than an email in conveying complex information, but email may be far more efficient and equally effective in transmitting a simple message to a large group of people. The path of the message is also important, especially if the message travels through multiple recipients before reaching its final intended destination – this may introduce losses in some attributes of the message and amplifications, intentional or otherwise, in others. The goal of this research is to examine the effectiveness of one such medium, a Balanced Scorecard (as introduced by Kaplan and Norton), and the communication network that its intended messages must traverse, namely a large aerospace organization.

1.1 Key Concepts and Definitions

A formal definition of “Organizational Communication” and other nomenclature as it is used in this document is necessary prior to discussing the details of the study. For the purposes of this study, “Organizational Communication” is defined as *the purposeful transmission of information necessary for the cost effective execution of operations and implementation of strategy*. The informational domain of organizational communication is wide. It includes the strategic goals of the business, the values and ethical standards of its leadership and employees, and the direction needed to achieve these ends. It also includes prescriptive definitions of individual roles and business processes, quantitative assessments of process and individual performance, and the authorization to allocate and

utilize resources. Finally, it is necessary for the dissemination and accumulation of knowledge, both proprietary/technical and business “savvy”.

“Communication Effectiveness” is defined as *the likelihood of a discrete communication to elicit a desired action*. If the likelihood of the desired result is low, then so is the effectiveness of the communication. “Communication Dynamics” is defined as *the transient informational phenomena that naturally occur in the context of a network*. These dynamics can best be expressed by Figure 1 which shows a simplified communication feedback loop. Coming into the loop on the left is a management directive or goal. At the first intersection, the goal is evaluated against the current status of the organization in meeting it. The resulting “gap” between status and the desired goal becomes an input into the organization which then acts on the input. The results of the action are measured, typically by some sort of business metric and reviewed by the team via the feedback loop shown. The gain on this feedback loop is determined by those reviewing the data – management typically – and their collective level of satisfaction or dissatisfaction. If the gap between the goal and the status widens, more urgency or importance is placed on the action the next time around, and activity is adjusted to close the gap. The cycle time of this loop may vary depending on the activity and the discretion of management; one cycle could be a day, a week, a year, or an hour. Also, the management goals which are the first input into the loop may change. There are also time lags between each step during which the status may still be changing. The resulting activity levels and performance over a time period consisting of many cycles of this loop may be defined as Communication Dynamics.

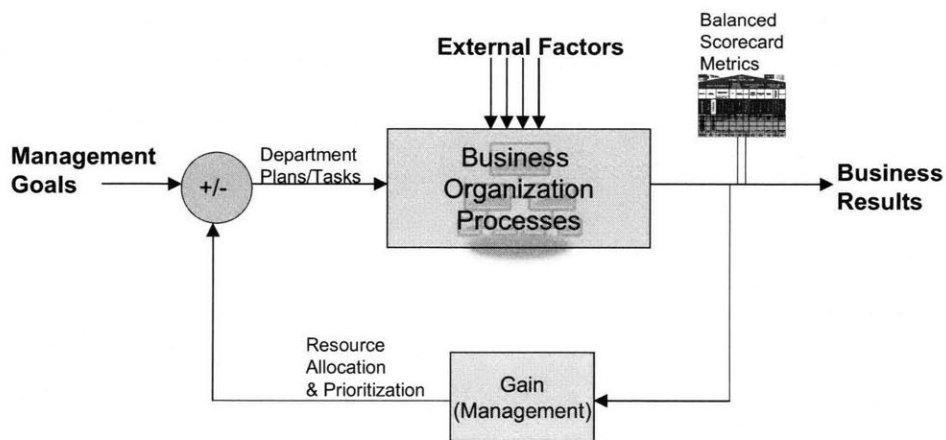


Figure 1. Typical Business Organization Feedback Model

1.2 Communication Problems and Opportunities for Misinformation

Given the dynamic nature of organizational communication, the influence of media and network path on message transmission, and the relative complexities underlying the message, there are many opportunities for problems that lead to communication failure. “Communication Failure” in this study is defined as *the inability of the message to elicit the desired action*. This “failure” may have many root causes: the message may simply never be received by the appropriate recipient; the message may arrive too late; the recipient may not understand the message; the recipient may not know what the appropriate response is; the message may require the agreement and cooperation of multiple recipients and fail to attain either; or the message may simply be unreadable or simply wrong in its content. Often it is the last reason that many latch onto in times of crisis, but the truth is that any of the others may be equally or more likely to be the root cause. Addressing the root cause of “simply wrong” messages is difficult, as it is usually dependent on the individual nature of the sender, but it is less difficult to address the other root causes to increase the probability of the successful transmission of a “right” message.

Over the past 4 decades, the organizational structures of large companies have evolved along with the tools they use to ensure efficient and effective organizational communication. Two emergent practices, Matrix Management and the Balanced Scorecard, have endured the test of time as well as the introduction of electronic “real time” feedback, but they are not immune to communication pitfalls. This study examines these two emergent practices and their general influence on communication efficiency and effectiveness.

Goal of this Thesis

The intended goal of this thesis is to apply a quantitative analytical approach in a particular case study – that of the Communication Effectiveness of the Balanced Scorecard within a Large Matrix-Managed Aerospace Business – to gain insight into the general problem of human communication in a business context. Success in the study will be measured in its ability to glean measures of communication success and failure

and the attributes of a business – such as organizational structure or culture – that may predict communication success or failure.

2 LITERATURE REVIEW

2.1 Research Approach

Scholarly literature on the subject of communication is abundant. In fact, it may be safe to say that human communication and its inherent complexity and problems are the inspiration for art as well as science. This study first narrows this large scope down to the communication of internal business information in the context of a matrix-managed workplace that designs and manufactures hardware for use in aircrafts or spacecrafts. It further narrows the scope by examining the effectiveness of only one medium of internal business communication, a popular management tool known as the Balanced Scorecard¹ which communicates performance measures for the organization. Indeed, achieving and maintaining a desired level for these performance measures serves as both a management input and a feedback input in the simple feedback model introduced in Figure 1. But the Scorecard begs the question: “Is it efficient and effective?” To answer this question, research was needed on the following subjects:

- The quantifiable mechanics of the flow of information in the context of the media through which it travels.
- Understanding the content and desired outcomes – i.e. the intended message – of the Balanced Scorecard, both generally and specifically to this case study.

2.2 Understanding the Mechanics of Communication

A student of electronic communication theory is likely to be familiar with Shannon’s “The Mathematical Theory of Communication” coupled with the excellent addendum provided by Warren Weaver². This seminal work introduced a quantifiable definition of information content, its codification and decodification, and the concepts of medium bandwidth and “noise” in the transmission of information. These concepts are

¹ Kaplan, Robert S., and Norton, David P., “The Balanced Scorecard: Measures that Drive Performance”, Harvard Business Review, 1992.

² Shannon, Claude S. and Weaver, Warren, The Mathematical Theory of Communication, 1963 Illini Books edition, 1949, 1963.

important for understanding what happens to a message from its initial conception at the originator to its final interpretation by its intended recipient. The many effects and transformations of a message are categorized into three levels according to Weaver's introduction to Shannon's paper:

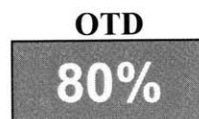
- 1) Level A Problem: How accurately can the symbols of communication be transmitted?
- 2) Level B Problem: How precisely do the transmitted symbols convey the desired meaning?
- 3) Level C Problem: How effectively does the received meaning affect conduct [of the message recipient] in the desired way?³

Case 1: Illustrative Example for On-Time Delivery

The simple case of an "On-Time Delivery" (OTD) metric provides an illustration of these types of problems. In this example, it is the intent of the company president to communicate to employees via the Balanced Scorecard the following information:

- Achieving and maintaining a minimum level of 98% OTD performance is important to the company
- Last week, the company shipped 100 parts against a total of 125 requirements.
- This level of performance is completely unacceptable.
- Improvement of OTD performance for the current week is more important than any other job anyone is currently working.
- Procurement work with the supplier of Part A, whose lateness prevented the shipment of 15 of the parts last week.
- Operations must speed up cycle times of the 5-axis machine to increase throughput of Part B.
- Engineering must help operations with a down-time issue on the machine that provides part C and design a solution to prevent the problem from occurring again.
- And so on...

The message on the Balanced Scorecard chart looked like this (with a red background):



³ Ibid p. 4

Table 1 summarizes some of the potential communication problems which could occur from this message transmission and categorizes them into Shannon and Weaver’s strata of communication issues.

Communication Category	Potential Problems	Potential Mitigations
Level A: Symbol Transmission	Is the metric readable?	Large fonts, big chart
	Can people see it?	Placement in high traffic area
Level B: Semantics	What does "OTD" mean?	Simple training or orientation program on how to interpret the metrics
	What does the quantity "80%" represent?	
	What is the reason for red?	
Level C: Meaning	Which parts were late? Why?	Awareness of cell metrics
	Who was responsible for the late parts?	Knowledge of business processes and individual roles
	Is OTD more important than my other activities this week?	Supplementary management communication
	Is 80% really that bad?	Cultural Influence
	What actions should I take?	Knowledge of role in larger organizational context

Table 1. Shannon Communication Problems in simple “OTD” Case

The lesson from this example is that there are few symbols to read, but there is a large amount of intended meaning behind them. The originator (the company president) appears to assume that much of this meaning is understood by the intended recipients and that by simply posting this metric in a widely viewed area, all employees will act immediately toward rectifying it within the roles that they perform. As the case illustrates, this is quite an assumption. Shannon calls it “entropy”⁴, which can be more or less defined as all of the implied meaning represented by a symbol. The symbols in this case are the letters, numbers, and color of the metric. While Level A problems can be easily managed in this instance, and Level B problems can be mitigated by some relatively simple employee training, the opportunities for Level C problems are nearly boundless and require experience, cultural indoctrination, and in many cases continuous reinforcement by management. In a business these things cost money, so a primary goal of the leadership becomes the conveyance and formatting of critical information for quick

⁴ Ibid pp. 12-13

processing by recipients, to help ensure an appropriate response by the organization soon follows.

While Shannon and Weaver's work focused on message content and the quality and quantity of information transmission, social networking theories examine the aspects of the message path by applying graph network models to social organizations such as the employees in a business. Of the high volume of academic papers on varieties of social network models, Dodds, Watts, and Sabel's (DWS in subsequent nomenclature) introduction of the mapping of organizational hierarchical structure onto otherwise random graph network models provides a particular insight that is central to this study⁵. Using a graph network model where each node in the network is an individual employee in the organization having the attributes of rank and department, the authors established rules that governed the probability of a message being transmitted from one node to any other node in the network. They were able to apply this rule to a path of multiple nodes. By iterating for every node in a non-repeating pattern, they could predict points of information traffic congestion which could result in the message not reaching its intended destination. They were also able to examine the influences of message volatility, task decomposability, and structural and cultural influences that manifest themselves as "characteristic path lengths" in the vertical and horizontal directions within the organization. By varying these attributes, they were able to conclude from the model which types of organizational structure were more or less susceptible to the congestion failure problem. A hybrid "multi-scale" network – possibly representing a matrix-type organizational structure – provided the optimal informational flow distribution under a variety of influences⁶.

Case 2: Analytical Comparison of the DWS "Multi-Scale" network with a typical matrix-managed organization.

DWS introduced several parameters in their model to observe the resultant effects on message traffic within the network. The two most important are employee rank and the

⁵ Dodds, Peter S.; Watts, Duncan J.; and Sabel, Charles F., "Informational Exchange and the Robustness of Organizational Networks," Periodical for the National Academy of Sciences, Volume 100, October 2003.

⁶ Ibid., pp. 4-6.

organizational distance from one employee to another. Figure 2 is pulled directly from the DWS paper to help illustrate the concept.

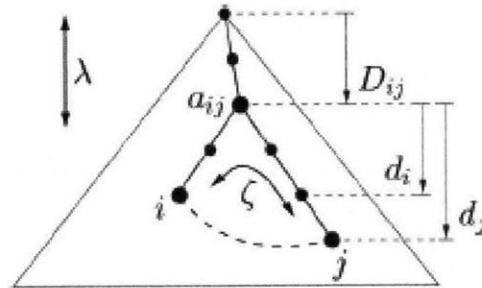


Figure 2. DWS illustration⁷ of employee rank and organizational distance.

The first critical parameter “L” simply defines an employee’s rank. A common practice in big organizations is to designate “Level 1”, or “L1”, as the company president, “L2” as his or her vice presidents, and so on. The parameter “λ” is a characteristic value of a particular organization – most likely culturally influenced – that defines the maximum “vertical distance” between any two nodes beyond which forming a communication link is highly unlikely. For example, it is very likely that a communication link will form at a vertical distance of “1”, as this distance is merely the distance between an employee and his or her supervisor. However, it is easy to see in many companies that this probability tends to decrease as this vertical distance increases; an introductory level new-hire is not likely to interact frequently with a Vice President, if at all.

In a more horizontal direction, there is a parameter x_{ij} that represents the organizational distance between any two employees i and j . This parameter recognizes the formation of departments within the network and that two employees may be less likely to communicate – though they may be of the same level – if they are in different departments than if they are in the same department. The value for “x” between two nodes is calculated as $(d_i^2 + d_j^2 - 2)^{1/2}$. Similarly as to the case of “λ”, there is a parameter “ζ” that represents a characteristic of a particular organization that defines the maximum value of “x” beyond which the probability of forming a communication link is

⁷ Ibid, Figure 1, p.2

very small. Using the following expression⁸ to determine the probability of communication between any two nodes i and j –

$$P(i, j) \propto e^{-D_{ij}/\lambda} * e^{-x_{ij}/\zeta}$$

where D_{ij} represents the rank of the lowest common ancestor to nodes i and j , multiple simulations of the network model could be performed for varying message path lengths and organization sizes. Using the concept of centrality in network models to determine the congestion level of any node, a topographical plot for centrality – or “ ρ ” – was generated (see Figure 3) for an organization of 3,905 employees (nodes) having 6 rank levels with 5 employees per supervisor, by varying values of λ and ζ :

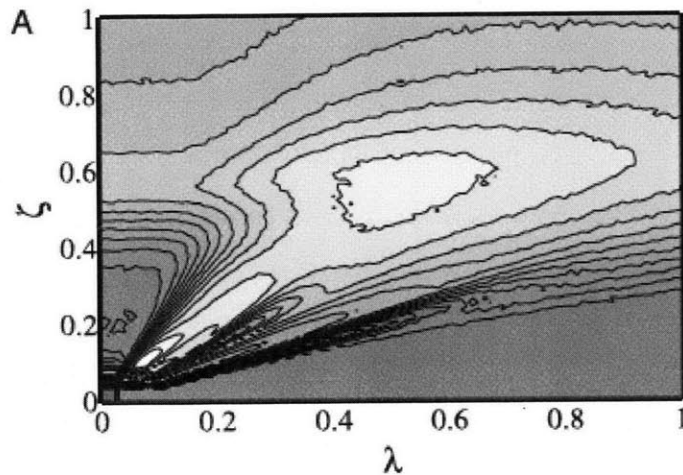


Figure 3. Topographical plot of ρ_{max} (lighter color represents decreasing value)⁹

DWS also mapped different business organization types as shown in Figure 4. Examination of each figure shows the Multi-scale network as mapping to the area of lowest congestion.

⁸ Ibid, Equation 1, p. 2

⁹ Ibid, Figure 3A, p. 4

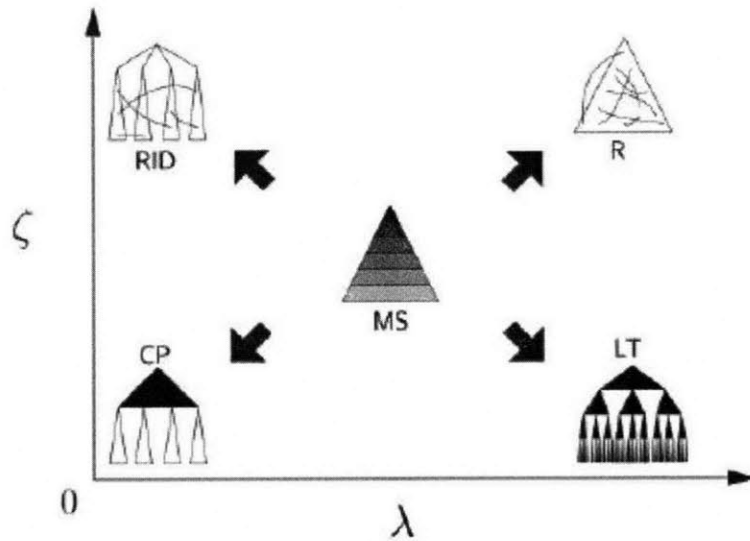


Figure 4. Different organization types mapped against λ and ζ ¹⁰

As higher congestion, or centrality, logically produces an increased likelihood of a communication failure, it is desirable for the company's management to minimize this congestion. DWS introduce additional parameters for the manipulation of the model and evaluation of its results. Table 2 below provides a complete list of these parameters, as well as those previously discussed, along with real-world examples illustrating the parameters and their interactions.

Further examination of the effects of an organization's industrial, cultural, and other influences on the independent variables λ , ζ , and ξ is necessary for trying to assess where the organization may be mapped onto Figure 3. This led to a second phase of research that focused on industry practices, again with focus on the nature of matrix organizations and the usage of the Balanced Scorecard.

¹⁰ Ibid, Figure 2, p. 3

Parameter	Definition	Real World Example
L	The organizational rank of a node.	President, VP, GM, Director, Manager, individual contributor represent levels 1 through 6.
λ	Characteristic max rank distance that a message may jump between two nodes, beyond which its probability is remote. This value is unique to a particular organization.	This value is sensitive to org structure, company culture, individual leadership traits, geographical locations of the nodes. How likely is a front-line manager going to contact her VP? Her Director?
x_{ij}	The organizational “distance” between two nodes i and j .	If a level 5 engineer directly contacts a same level Materials planner who shares the same GM, then $x_{ij} = \text{sqr}t(3^2+3^2-2) = 4$.
ζ	Characteristic max organizational distance a message may jump between two nodes, beyond which its probability is remote. This value is also unique to a particular organization.	How likely is the direct contact situation in the example above in your company? Like λ , ζ will depend on org structure, culture, geographical location, and other factors. Will there be local pockets of high ζ values?
D_{ij}	The rank of the least common ancestor of any two nodes.	In the examples for L and x_{ij} above, this value corresponds to the GM’s rank of 3.
μ	The rate of information exchange, equal to the average number of messages that must be transmitted by a single node in a single time step. A high value indicates high communication volatility, and vice versa.	In an organization of 1000 nodes with a time step of one day, if 100,000 messages must be processed per day to sustain operations then the average rate of exchange per node, μ , is equal to 100. How many discrete messages travel in a single email? A phone call? A face-to-face conversation or meeting?
ρ_i	The congestion centrality at a node i , the probability that any given message will be processed by this node.	Information bottlenecks will naturally form in a network. These bottlenecks exhibit ρ_{max} plotted in Figure 3, and are the most likely communication failure points in an organization due to human bandwidth limitations. Braha, et. al. observed that these congestion points may be dynamic. ¹¹
ξ	A measure of task decomposability within an organization. Large values represent non-decomposable and complex tasks; small values represent highly decomposable tasks. This measure influences the message path; a high value will usually dictate the message needs to travel to nodes of different rank and department. Low values dictate the message will rarely have to exit the department	No business tasks are perfectly decomposable, just as no tasks are absolutely non-decomposable; so ξ is never 0 or infinity (respectively). In Figure 3, ξ was set equal to 1 for the simulation. In the DWS model, the probability of a target node for a message is dictated by the value of $\exp(-x/\xi)$. Simply stated, this value dictates the likelihood a node will have to contact a higher level or different department, or both, to complete a task; this will affect information traffic flow patterns and may create new areas and levels of congestion centrality.
R_i	The max number of messages a node can process in a single time step. If the traffic exceeds this bandwidth, messages start being dropped, leading to a communication failure.	How many emails, phone calls, meeting actions, and other communications can the average employee effectively respond to on a given day? Does this bandwidth change from level to level? In the analysis, R_i must be greater than $\mu N \rho_i$ to avoid communication failure.
N	The total number of nodes in the network or business organization	A large organization can easily have 10,000 total nodes, but may form separate “independent” business units exhibiting business/customer decomposability. It is very likely this high level decomposability creates different subcultures (different λ and ζ) in the different business units.

Table 2. Summary of DWS parameters

2.3 Current Industry Practices

The Matrix-Managed Organization

The first common industry practice in this study for facilitating communication was the onset of the Matrix-managed business. Sayles posited in the mid 1970’s that the cyclical formation and dissolution of matrix-like systems was a natural business phenomena that resulted from the cyclical needs to decompose problems (to departmentalize and flatten) and then to integrate and deliver a final solution (to

¹¹ Braha, Dan, and Bar-Yam, Yaneeer, “From Centrality to Temporary Fame: Dynamic Centrality in Complex Networks”, *Complexity*, Wiley Periodicals, Inc., 2006.

centralize and make tall)¹². He further introduced five different types of matrix organizations that were differentiated by the allocation of specific roles for system managers and functional managers.¹³ This allocation usually depended on where the business complexity lay – it could be technical product complexity, the size of the distribution network, or the geographical characteristics of its customer base among many other things. Sayles acknowledged management problems this could cause, namely “over-defined jobs in which there are more requirements than can possibly be met and conflicting goals that make tradeoffs between them continually necessary.”¹⁴ Thus one may conclude that one goal of matrix management was in reducing the value of the DWS parameter of ξ , or task decomposability, to simplify and shorten the necessary message paths.

Galbraith, a contemporary of Sayles, wrote many articles and books analyzing the problems with managing complexity, particularly stressing the need for excellent lateral communication between departments, business units, and geographical locations.¹⁵ From a DWS perspective, these measures seek higher values of ζ , the organizational characteristic that dictates the probability of two distantly separated lateral nodes establishing a communication link. Carlile performed a case study within one organization that identified the tools departments use to “translate” results from one department into action from another. He called these communication tools “boundary objects”¹⁶, which basically format complex information from one department (such as engineering) into a usable form for another department (such as operations or purchasing), using engineering drawings and specifications as an example. These tools influence both ζ and ξ by facilitating lateral communication and decomposing complex messages into usable forms for different departments.

¹² Sayles, Leonard R., “Matrix Management: The Structure with a Future”, Organizational Dynamics, Fall 1976, pp. 1-3.

¹³ Ibid., Figure 2, p. 7.

¹⁴ Ibid., p. 15.

¹⁵ Galbraith, Jay, Designing Complex Organizations, Addison-Wesley, 1974.

¹⁶ Carlile, Paul R., “A pragmatic view of knowledge and boundaries: Boundary Objects in New Product Development,” [Journal Unknown], July 2002.

Davis and Lawrence classified problems with matrix organizations into nine categories¹⁷, each unique in manifestation, but all more or less having the same root cause: role and responsibility ambiguity caused by poor management communication to their employees. In the DWS context, this possibly highlights poor vertical communication which would result in a low value of λ . In a study of matrix-management adoption in the Hong Kong public construction sector, Rowlinson found that national cultural influences had a strong effect on the rate and success of matrix adoption. This article also serves to highlight the influence of national and local cultures on other aspects of the business, which would include organizational communication.¹⁸ Burns and Wholey examine both the pre-disposition (or local culture) of a company and the social network effects on the likelihood of the adoption or abandonment of matrix management, but defining the latter network as the general industry with each node being a business within that industry.¹⁹ This work highlights another influence on DWS parameters, that of the industrial social network. It also may indirectly imply that management practices for improving communication may be ineffective if perceived to be just another management “fad.” This can undermine the confidence or trust that employees place with management and can create “noise” in the Shannon sense.

One final important work that has particular relevance to the DWS model is Allen’s research on individual and social psychological influences on information dissemination patterns.²⁰ These include personal and educational backgrounds, professional status perceptions, social networks established by simple co-location, and the “time-constant” associated with establishing individual credibility with peers (a problem often seen where attrition is high). While the former two are typically outside of the management control, the latter two offer some management leverage, especially the co-location of project resources. This method seeks to overcome issues with low values

¹⁷ Davis, Stanley M., and Lawrence, Paul R., “Problems of Matrix Organizations”, Harvard Business Review, May-June 1978.

¹⁸ Rowlinson, Steve, “Matrix organizational structure, culture, and commitment: a Hong Kong public sector case study of change,” Construction Management and Economics, 2001.

¹⁹ Burns, Lawton R., and Wholey, Douglas R., “Adoption and Abandonment of Matrix Management Programs: Effects of Organizational Characteristics and Interorganizational Networks”, Academy of Management Journal, volume 36, 1993.

²⁰ Allen, Thomas J., Managing the Flow of Technology, The Massachusetts Institute of Technology, 1977.

of λ and ζ by physically locating these organizationally separate nodes in a common geographical area.

The Balanced Scorecard

What is the intended purpose of a “Balanced Scorecard” and why have businesses attributed so much success to its adoption? The Balanced Scorecard was introduced in name and philosophy by Kaplan and Norton in the early 1990’s.²¹ The authors proposed that financial metrics alone did not necessarily dictate current success, and were poor for predicting future success. Rather, additional measures of the business’s core processes should also be monitored to help management determine how to best allocate resources and which processes needed improvement. If maintained on a regular basis as recommended, the scorecard becomes a continuously updating information feedback source for management, essentially providing the feedback discussed relative to Figure 1. Indeed, the Scorecard is intended to act as an information “integrator”, monitoring the end results that come from the intricate informational decompositions performed in the beginning (the decomposition process itself may be similarly acting in the information loop as a differentiator) and the operational processes re-integrating this activity into a physical product or service that the business then converts into cash.

First, the Scorecard is a communication tool. In the context of the previous literature, it may best be categorized as one of Carlile’s “boundary objects” for transforming process data into performance and strategic data that management can immediately act upon. From a Shannon perspective, the medium of communication is typically a 1-page visual chart with quantitative values representing the current states and trends of what are deemed as the most critical business process metrics. Typically color coding is applied to the data to indicate some kind disposition on the status of this data when compared to management goals – green is usually healthy, while red and yellow indicate two degrees of problem intensity. It is implied that the mere fact that a process is being measured on the scorecard means that leadership has concluded it is important to the company. If there are significant gaps (significance of the gap is indicated by the color) between the current status and the desired status (which the authors also

²¹ Ibid, Kaplan and Norton.

recommend to be included on the chart), there is another implied message that employees should re-focus their efforts onto tasks which reduce these gaps. Finally, the accuracy and objectivity of the data presented should be trusted by its intended audience. Table 3 summarizes the key informational attributes the Scorecard intends to convey in terms of Shannon and Weaver’s Communication Categorizations from Table 1, and also provides real examples of how this communication is or may be implemented. It is the hope of management that all of Shannon’s categories of information – Levels A, B, and C representing symbol readability, semantic accuracy, and intended meaning – are being satisfied to the full potential of this information medium. If this is being accomplished, then it satisfies the challenge of “Efficiency and Effectiveness” put forth in the Introduction when intents within the chart flow into the mind of a direct recipient. However, this effect likely decays if intermediaries are introduced between the chart and the final intended recipient.

Information Attribute	Shannon Category	Scorecard Example
Quantitative Assessment	Level A, Level B	The quantities of the goals and current quantities of the different metrics
Accuracy or Objectivity	Level C	Implied from high visibility (i.e. “it better be right”). Method of calculation usually also provided.
Importance or Priority	Level A, Level B	Proportional to the gap between status and goal, and indicated typically by color
Invitation to Act	Level C	Implied by priority status. Higher priorities required more immediate action.
Authorization to Proceed	Level C	Management assumes that employees act appropriately and according to their organizational roles to close unfavorable gaps.
Transparency	Level A, B, C	The posting of the Scorecard information in a “public” area; management is saying, “Here is what is important to the business and how well we are doing towards it. Let’s work together to improve the areas that need it.” It is meant to achieve resource and effort alignment.

Table 3. Information being transmitted by Scorecard.

What is the information that is intended to be communicated by the Scorecard? This constitutes the “message” that management is sending via this chosen medium, and it is not a simple question. Aside from the quantitative assessment and tactical messages on the surface, are there additional messages beneath? Do these additional messages

interfere with the surface messages, or with one another? With its single page, it is a concise statement intended for the eyes of the entire organization; for rapid consumption and fast action – a lot of “bang for the buck” for a single chart. Yet while this efficiency is desirable, is there enough bandwidth in the medium to distinguish the real message from the “noise”? While this type of emergent noise (if it exists) was probably never intended by the authors, wide adoption of the Scorecard was sure to spawn a variety of success stories when the Scorecard delivered as planned, as well as criticisms for when it did not.

Many case studies praised the scorecard’s adoption. The mayor of Atlanta, Georgia decided to adopt the scorecard to give visibility to the problem areas of crime and poor street maintenance.²² In this instance, the scorecard acted as a pure feedback loop that naturally gravitated resources to problem areas and appeared to produce improvements quickly. It also provided transparency to external customers – the voting public – regarding the actions public officials were taking for the good of the city, something which the authors imply was noticeably missing from previous administrations.²³ In another example, the Mayo Clinic in Rochester, Minnesota (the oldest and largest in the Foundation) adopted a similar Scorecard or Dashboard system.²⁴ Under pressure to provide more accountability around operational costs and service quality as well as general corporate adoption of Dashboard-type systems, the Rochester Clinic chose to adopt and tailor a similar system around their operation. In the process of creating and implementing the system, administrators learned that there was a strong latent need for the information the dashboard provided and that more information infrastructure would be needed to efficiently supply this need. They also learned that the dashboard had multiple audiences with different interests – and often different takeaways – from the same dashboard document, and that this generated an evolving need for more and different types of information.

²² Edwards, David, and Thomas, John C., “Developing a Municipal Performance Measurement System: Reflections on the Atlanta Dashboard,” *Public Administration Review*, vol. 65, May-June 2005.

²³ *Ibid.*, pp. 1-2.

²⁴ Curtwright, Jonathan; Stolp-Smith, Steven; and Edell, Eric, “Strategic Performance Management: Development of a Performance Management System at the Mayo Clinic,” *Journal of Healthcare Management*, January-February, 2000.

As the latter research supports the scorecard as a tactical communication success, the strategic aspect of the scorecard – the establishment of goals, tracking of intermediate milestones, and recognition of both the customer and internal resources as stakeholders – is also important. Atkinson²⁵ performed an exhaustive investigation on strategy implementation and the usage of the Balanced Scorecard. She concluded that the most common failure mode of strategic initiatives is in the initial communication and implementation, and that the Scorecard held promise as a tool which could address these issues with emphasis on its communication strengths. She also acknowledged that the Scorecard had shortcomings in its integration with legacy management tools but that these could be overcome with focused effort. In this respect, Pforsich²⁶ advises the integration of the Scorecard with a Control Self-Assessment tool, arguing that Scorecards on their own often fail because they do not effectively manage leadership’s expectations for performance gap closure. The Control Self-Assessment tool gives equal visibility to the tasks undertaken to improve metric performance; where the Scorecard tells “where to go”, the CSA tells “how to get there” and “how long it will take”. These were identified as key weaknesses of the scorecard – that it was not clear who had responsibility for improving the particular performance measure, what tasks they needed to perform to realize improvements, and what resources would be needed to complete these tasks. Similarly to these Management and Finance journal articles, other articles tying employee roles to strategic and tactical objectives showed up in Engineering Management and Quality Engineering journals. Burton and Pennotti²⁷ argue the benefits of value-stream-mapping the critical enterprise processes that directly influence Scorecard metrics so that departmental employee roles are clear and understood when the Scorecard highlights the need for action in a particular area. Indeed their process identifies the Scorecard as a critical informational feedback loop to integrate departmental efforts. Gitlow²⁸ provides

²⁵ Atkinson, Helen, “Strategy Implementation: A Role for the Balanced Scorecard?”, Management Decision, vol. 44 no. 10, 2006.

²⁶ Pforsich, Hugh, “Does your Scorecard need a Workshop? BSC and CSA: Merging Mutual Complements,” Strategic Finance, May 2005.

²⁷ Burton, Herbert O., and Pennotti, Michael C., “The Enterprise Map: A System for Implementing Strategy and Achieving Operational Excellence,” Engineering Management Journal, vol. 15 no. 3, September 2003.

²⁸ Gitlow, Howard S., “Organizational Dashboards: Steering an Organization Toward its Mission,” Quality Engineering, 2005.

an interesting application of System Engineering tools, chiefly House of Quality, for integrating strategic business objectives with information regarding the progress of various programs, even going so far as to establish weight factors for each program to advise in the allocation of limited shared resources. This is particularly interesting in that the Scorecard, while acting as an integrator for a particular program, may also serve at a higher strategic level to decompose programs and re-integrate the information again into overall strategic business objectives. Bracken and Hayes²⁹ write about the merits of the “360 degree Performance Feedback” tool for management to flow down employee responsibilities and goals to effectively tie their work to Scorecard objectives. One may conclude from the extensive information available on complementary tools for the Balanced Scorecard that it may have a general shortcoming in the aspects of the “what” and “how” with regard to closing performance gaps. It is the goal of this research to address this question, at least in part, with regard to why the Scorecard does not deliver this information sufficiently on its own.

3.0 DATA COLLECTION

3.1 Goal of the Study

The primary goal was to gather data from employees of a “typical” large matrix managed organization that could help in understanding the DWS model within a real world context. The Scorecard is a focal point that serves as a tap into the information stream before it branches out to its intended recipients in the organizational network. The observational study must gather data at another point in the flow path to understand what transformations take place in the information between Scorecard and recipient. This evidence of information loss or change between organization nodes provides clues for assessing absolute or relative values of the DWS parameters. The secondary goal of the experiment was to examine whether the content or complexity of a given message has a significant influence on the probability of its successful transmission, another prediction of the DWS model. At the conclusion of the experiment, there should be sufficient

²⁹ Bracken, David, and Hayes, Bryan, “Performance Management as a Business Process”, a brief descriptive article apparently written for Wikipedia, 2008 est.

information about the organization to gain at least some insight as to where it may be mapped on the DWS communication topography.

3.2 Data Collection Method

In this study, the pool of subjects consisted of all salaried employees within two major business units of the organization, totaling nearly eight hundred potential participants spanning a wide range of ranks and functions. A web-based survey was chosen to collect information for the study, as subjects all had access to work computers with internet access. This tool offered the convenience of anonymous participation (or refusal) at the employee's leisure, meaning the information collected was provided willfully and with no social pressure to answer questions in any way but honestly. The survey was also designed to take as little time to complete by the participant as possible, with a goal of 10 minutes or less. This advice was offered by some experts within the company that had experience administering surveys, explaining that participation is maximized the more brief the survey is. This practice also drove an economy of words and terminology into the survey questions that served to minimally constrain responses. After several trial surveys, a final version was adopted that would hopefully maximize participation without sacrificing information content.

The first piece of data needed for proper comparison to the model was basic demographic information from each employee. The two demographic attributes needed were rank and department. The rank is dictated by standard nomenclature defined by the organization and is provided in Table 4 below. Each rank has a standard title associated with it that implies some level of the individual's scope of responsibility within the business. The scope of responsibility at the management level is often measured as the number of employees managed, the amount of sales generated, the total budget or resource authority. At the individual contributor (IC) level, the title scope implies a certain level of competence and seniority. These levels are typical to each department up to a certain point dictated by the department's relative size within the organization – in other words, not every department necessarily needs a vice president. Last, it is typical within the management tier for members at one level to be managed by members of the

next higher level; below the first management tier (Level 4), IC's of any rank may report. Occasionally, managers may report to more senior managers of the same rank.

<u>Rank</u>	<u>Nomenclature</u>	<u>Descriptive Title</u>
1	Level 1, or L1	Division President
2	Level 2, or L2	Division Vice President
3	L3	Director or General Manager
4	L4	Manager, first tier
5	L5	Staff level individual contributor (IC)
6	L6	Senior level IC
7	L7	Associate level IC
8	L8	Entry level IC

Table 4. Rank nomenclature in the context of the business under study

The employee's department was also needed. It was decided to use functional departments instead of customer programs when grouping employees, though it could be debated which of the two choices was better. For purposes of this study, it was considered to be arbitrary, as both departments and programs exhibit common internal practices and exhibit some kind of internal employee camaraderie (i.e. there was program pride as well as functional pride). The departments chosen were:

1. Engineering
2. Program Office
3. Operations Support and Materials Management
4. Procurement
5. Quality
6. Contracts/ Business/ Finance
7. Environmental Health and Safety
8. Other

The next survey questions were designed to assess the transformation of information content along the message path originating with the Balanced Scorecard and ending at the individual employee. Rather than focusing on the specifics of the Scorecard metrics themselves (such as "Quality Escapes"), subjects were asked to assess levels of pre-selected informational attributes for each metric. These attributes were discussed

previously in Table 3 in the last section: Quantitative Assessment, Accuracy or Objectivity, Importance or Priority, Invitation to Act, Authorization to Proceed, and Transparency. It was here in the survey design that the terminology used had to be carefully chosen. The terms above are meaningful in an academic paper, but probably less so in a non-academic environment with high variance in experience and education. Also, there may not be clear or sufficient differentiation between these attributes for subjects to make a meaningful assessment. In the interests of keeping the survey brief and using plainer language, the following questions were asked for each of the Balanced Scorecard metrics, each using a 5-step gradation of responses:

1. Please rate each [Balanced Scorecard] Metric as to how hard or easy it is for you to UNDERSTAND. (1 = Very Hard, 2 = Hard, 3 = Moderate, 4 = Easy, 5 = Very Easy)
2. Please rate each [Balanced Scorecard] Metric as to the level of ACCURACY to which you believe it measures each indicator. (1 = Completely Inaccurate, 2 = Mostly Inaccurate, 3 = Somewhat Accurate, 4 = Mostly Accurate, 5 = Highly Accurate)
3. Please rate each [Balanced Scorecard] Metric as to what you think its IMPORTANCE is to [the organization]'s overall business success. (1 = Very Low, 2 = Low, 3 = Medium, 4 = High, 5 = Very High)
4. Please rate each [Balanced Scorecard] Metric as to what you think its level of IMPORTANCE is to the CUSTOMER. (1 = Very Low, 2 = Low, 3 = Medium, 4 = High, 5 = Very High)
5. Please rate each [Balanced Scorecard] Metric as to how much personal INFLUENCE you have toward making it change. (1 = No influence, 2 = Little Influence, 3 = Some Influence, 4 = Significant Influence, 5 = High Influence)

After each question, employees were invited to provide comments. Also a final open-ended question was added to poll employees on information they felt may be missing from the Scorecard:

6. What metric do you believe is missing from the [Balanced Scorecard], if any? If none, please type "None".

This final question along with the open-ended comments provided opportunities for employees to fill in any informational gaps between the survey questions themselves and the list of attributes from Table 3.

Discussion on Choice of Survey Questions

The choices of questions for the survey require justification for their deviation from the path laid out in Table 3. It was important that the questions not contain long explanations on terminology, as this could both lower participation and confuse the participant as well as the results. Therefore it was imperative to keep the questions as simple and as relatable as possible across ranks and departments, but not so much so as to sacrifice the quality of the survey data captured. Table 5 presents Table 3 attributes mapped against the simplified terminology along with the rationale for the choice of the new terminology.

Information Attribute	Simplified Terminology	Rationale for changing terminology
Quantitative Assessment	“Understandability”	Question 1 basically asks “Do you understand what the presented quantity represents?” More subtly, it also asks if the participant understands the organizational activity that produced this quantity, and if the quantity has a clear meaning for the participant, but this interpretation of the question will vary between participants.
Accuracy or Objectivity	“Accuracy”	Question 2 gives participants an opportunity to challenge the accuracy of each metric. Typically if someone trusts the accuracy of a measure, they are in a sense certifying that the measurement is objective and not subject to further interpretation.
Importance or Priority	“Importance”	Importance is the most susceptible to communication dynamics. Maybe more properly said, “priority” is the dynamic state of “importance”. All metrics may be “Important”, but their priorities may differ based on current state. The survey seeks to measure “Importance” in this sense, a property that is culturally influenced and may be considered the cumulative state of “priority. This attribute was given two questions to capture two perspectives: the internal business and the customer. As these perspectives often can conflict, Importance was deliberately split between the two perspectives to prevent participants from having to choose between the two and thus confound the results.
Invitation to Act	“Influenceability”	The term “influence” – presented as the influence of the individual being surveyed – was chosen to capture the final 3 attributes, though the match is probably less direct than the previous examples. It captures the invitation to act by implying the participant is knowledgeable regarding his role in addressing the metric; authorization to proceed is closely linked to the invitation to act – authorization is essentially granted provided the choice of action is the correct one (another complex assumption). “Transparency” is captured by the implied universal accountability to the metrics – it is assumed everyone sees the same message; more interestingly and perhaps subtly, it is assumed that <i>everyone sees</i> that everyone sees the message, hence the transparency aspect.
Authorization to Proceed		
Transparency		

Table 5. Table 3 information attributes mapped to simplified Survey terminology

The survey was released in voluntary cooperation with the two business units' communications managers, and permission from the division vice presidents was gained prior to its release. Indeed, some of the modifications made to the survey were made based on their valuable input. The opening of the survey was communicated via an email announcement sent to the division units' complete distribution list with an invitation message written by the thesis author and distributed via the organization's communications managers. It remained open for input for nearly 3 weeks, with a final reminder sent at the beginning of the final week. A total of 238 usable responses were received out of 760 total surveyed.

3.3 The Organization's Balanced Scorecard

Before proceeding to the Results of the survey, Appendix 1 provides a snapshot of the Balanced Scorecard for the combined business units being studied (data values are disguised). In keeping with Balanced Scorecard philosophy, the metrics are grouped into higher level categories of Customer Value and Satisfaction; Business (Financial) Performance; Process, Product and Service Excellence; and Leadership, Cultural, and Environment. Customer Satisfaction Survey results for the current year are contained in the upper left corner of the Scorecard, and Employee Satisfaction is shown at the upper right – these two are measured once per year, while the remaining metrics are monitored monthly. Metric goals are communicated on the chart as well as status toward reaching those goals. Instead of commonly used colors such as red (for bad), yellow, and green (for good), the colors of gold (best), silver (satisfactory), and red (less than satisfactory) are used to communicate gaps between status and goal, indicating a relative priority of management concern. Each metric has a person who provides the quantitative data as well as someone who has ultimate responsibility for managing the metric toward its goal.

Each survey participant was asked to rate each metric (as phrased in the previous section) on the Balanced Scorecard for Understandability, Accuracy, Internal Importance, Customer Importance, and Influenceability. Participants were also asked for comments and to provide any metrics they thought were “missing” from the scorecard. The metrics questioned were:

- a) Delivery Performance – measured as the percent of deliveries scheduled in the current month that were delivered to the customer on time.
- b) Confirmed [Quality] Escapes to the Customer – measured as the number of escapes that occurred in the current month. An “escape” is defined as a defective product that went undetected by the organization until it was sold to the customer. For the survey, total escapes were questioned, a combination of “Significant” and “Other” escapes.
- c) Earnings Before Interest and Taxes (EBIT) – measured as the percentage of monthly goal achieved with 100% as the goal.
- d) Company Funded Engineering (CFE) – measured as the percentage of dollars spent against the monthly plan. Goal is to be less than 100% of plan.
- e) Passport – measured as the percentage of Passport reviews completed within the time requirement dictated in the process description. The term “Passport” is organization-specific, referring to a gated series of mandatory executive reviews that coincide with all the significant product development milestones. Goal is 90% or better.
- f) Program Schedule Performance (Cumulative Year-to-Date) – the cumulative current year Schedule performance for all programs as defined by standard Earned Value Management System (EVMS) practices. Goal is 0.95 or better.
- g) Program Cost Performance (Cumulative Year-to-Date) – the cumulative current year Cost performance for all programs as defined by standard EVMS practices. Goal is 0.95 or better.
- h) Employee Training – measured as the percentage of employees trained to the specific business need. Goal is 90% or better.
- i) Communication Effectiveness – measured by surveying employees at the end of general communications. The goal is 90% or better each month
- j) Total Recordable Incident Rate / Lost Work Incident Rate (TRIR/LWIR) – standard employee safety metrics describing the rate per

total employee population of work-related injuries resulting meeting “recordable incident” criteria or lost work.

The Balanced Scorecard is updated every month and monthly status retained for each month of the current year to observe trends. Executive leadership is assigned the task of eventually reaching a “Gold” status (criteria included in the upper right corner of the chart) by a certain time for every major business unit. This status is attained by both reaching and sustaining the metric goal levels for a prescribed time period. The management philosophy is that by attaining these goals and developing robust processes to sustain this level of performance, business success will be achieved.

4 RESULTS AND DISCUSSION

4.1 Demographic Participation

A total of 238 participants provided usable responses out of 760 surveyed. Table 6 shows the percentage of total respondents by department with the two largest groups each responding approximately 30% of the time; Figure 5 provides details of the demographic breakdown of participants by department; Figure 6 shows a similar breakdown by employee rank; Table 7 breaks out employee ranks by Department.

Department	% Participation
Engineering	29%
Program Office	28%
Ops and Materials	60%
Procurement	64%
Quality	28%
Contracts/Bus/Fin	71%
EH&S	0%
Other	60%

Table 6. Percentage Total Participation by Department

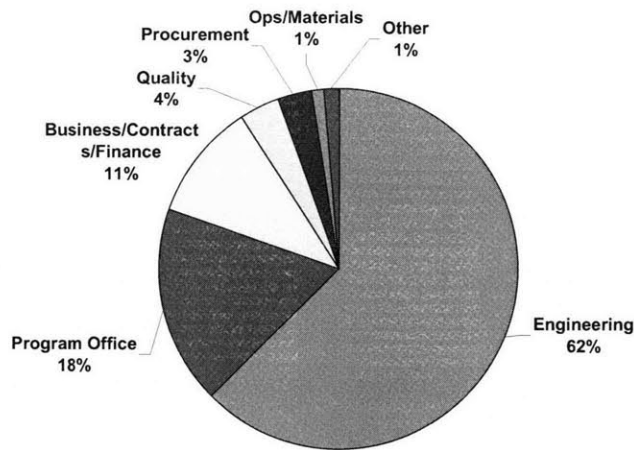


Figure 5. Total participants breakdown by Department

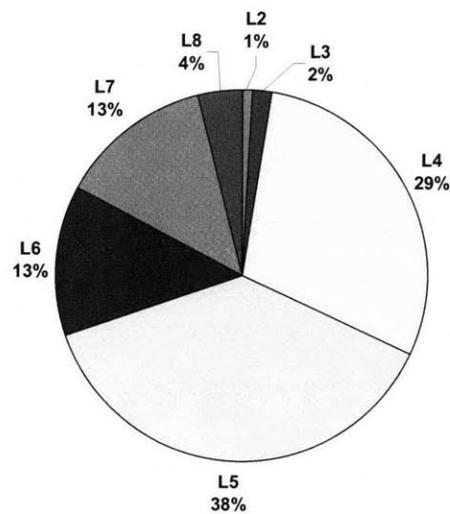


Figure 6. Total participants breakdown by Employee Rank

Bus/Contracts/Fin		Engineering		Operations/Materials		Procurement		Program Office		Quality		Other	
Rank	Qty	Rank	Qty	Rank	Qty	Rank	Qty	Rank	Qty	Rank	Qty	Rank	Qty
L2	0	L2	1	L2	0	L2	0	L2	1	L2	0	L2	0
L3	0	L3	2	L3	0	L3	0	L3	1	L3	1	L3	0
L4	8	L4	33	L4	0	L4	0	L4	28	L4	0	L4	1
L5	8	L5	62	L5	3	L5	6	L5	5	L5	5	L5	1
L6	4	L6	20	L6	0	L6	1	L6	4	L6	2	L6	0
L7	3	L7	25	L7	0	L7	0	L7	3	L7	1	L7	0
L8	2	L8	6	L8	0	L8	0	L8	0	L8	0	L8	1
Total:	25	Total:	149	Total:	3	Total:	7	Total:	42	Total:	9	Total:	3

Table 7. Breakdown of Employee Rank by Department

Of note, Engineering and Program Office had both the largest participation and highest rank diversity of all the departments surveyed. Because of the high turnout and rank diversity, these departments are studied in detail in a subsequent section of this report. It is recognized that much higher participation would be needed to minimize “participant bias”, the response was large enough to give a meaningful sample of communication in this organization. The Environmental, Health, and Safety did not have any participants in the survey; this is not a large concern because EH&S is a very small department. Also of note, Operations/Materials, Procurement, and Quality groups had small representation. This effect is a by-product of the organization’s implementation of its matrix management structure. These employees come from a much larger pool, overall Operations, whose remaining employees and senior management fall outside the scope of the business units being studied. The participants from this department are “dotted line” resources dedicated specifically to support the two business units being studied. Engineering respondents also fall into this category of “dotted line”, but simply have a larger number of employees due to the complex technical nature of the products.

4.2 General Results for the Entire Population

A basic statistical analysis was conducted for the informational attributes underlying each metric on the Balanced Scorecard. First, a correlation analysis was performed for the five attributes being measured: Understandability, Accuracy, Internal Importance, Customer Importance, and Influenceability. Next, the Average, Range of Averages, and Standard Deviations were computed for each attribute, within each department and each employee rank, for all the metrics on the Balanced Scorecard. Average values represent general attribute levels within a department or rank. The range of averages across a department or rank indicates an average range of “disagreement” about the attributes between different ranks or departments. For example, the attribute of Understanding when applied to the Hardware Delivery metric may have an average level of 2.3 for L7 employees and an average level of 4.8 among L3 employees. If these two values represent the minimum and maximum levels, respectively, for all employee ranks, then the range of averages is computed to be 2.5 for this metric. This “disagreement” implies the message has been transformed and interpreted differently on average by L7’s

and L3's and provides clues as to the influence of these employee characteristics on the communication of Balanced Scorecard data. Similarly, standard deviation *within* a single department or rank is a possible indicator of various communication successes and failures causing variance in individual employee interpretations from the "true meaning of the message" behind each metric. Interpreted this way, increasing standard deviation values are an indicator of an increasing lack of communication effectiveness because essentially not everyone is receiving the same message.

4.2.1 Informational Attribute Correlation Analysis

Figure 7 shows the correlation factors for each pairing of informational attributes. The first observation is that all pairings had a positive correlation; the average correlation coefficient was 0.348. This is probably due to Test Taker's Bias – employees who give higher ratings in one area do so in others. This can arise because some employees rate the attributes higher because a lower rating may reflect negatively on their self-perception of their technical and business competence and influence. It is unclear where the real zero-level is for the results, but it appears from the data that Understandability/Accuracy and Internal/Customer Importance have stronger interdependency than the remaining attribute pairings. It also appears that Accuracy and Customer Importance attributes have a low correlation, possibly even a negative one. There was insufficient differentiation among other attribute pairings to draw further correlation inferences.

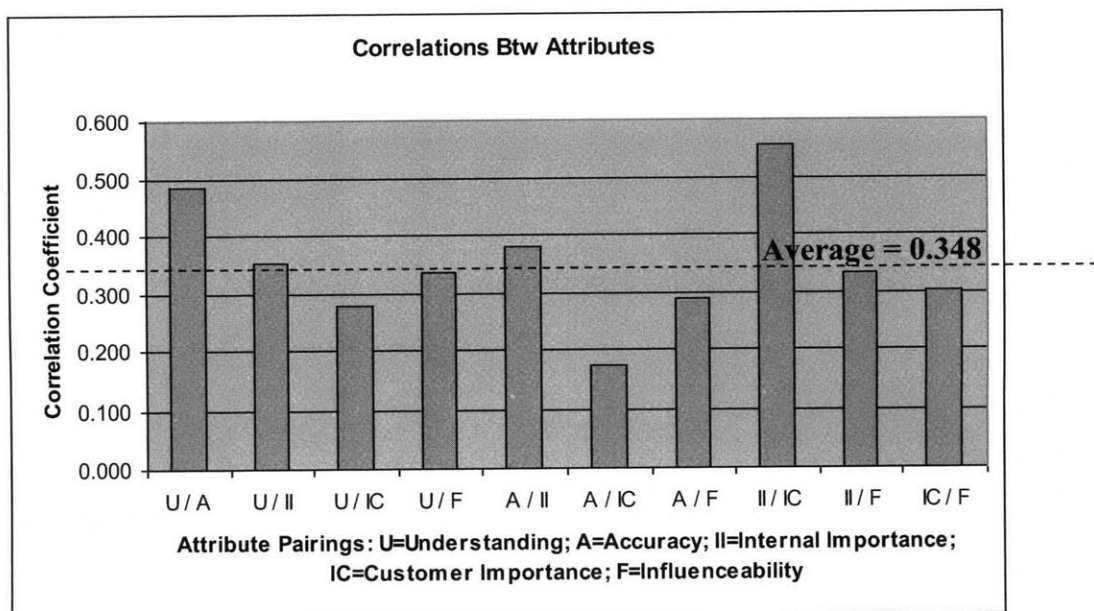


Figure 7. Correlation Analysis of Informational Attributes

4.2.2 Statistical Analysis of General Results

Each informational attribute was analyzed for its average, variance, and range of averages across department and rank. Figures 8 and 9 show the average attribute level and standard deviation, respectively, for each metric for the global survey population. From a brief inspection of Figure 8, it can be seen that Influenceability levels, with an average level of 2.77, are significantly lower than for the other attributes. Figure 9 shows that the average standard deviation level for all metrics is also highest for Influenceability. This implies that employees in general feel their individual influence on a metric is low, and they also disagree about the level of their personal influence more than they disagree about the other information attributes.

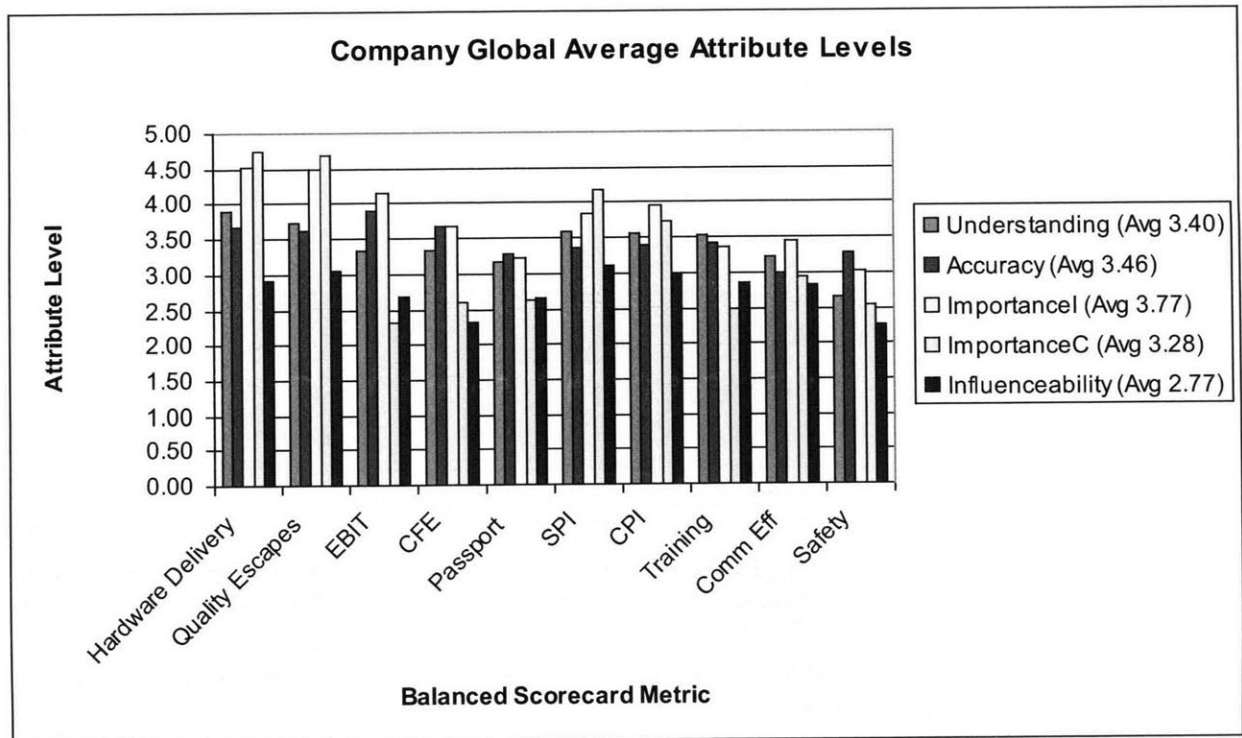


Figure 8. Average informational attribute levels for each metric

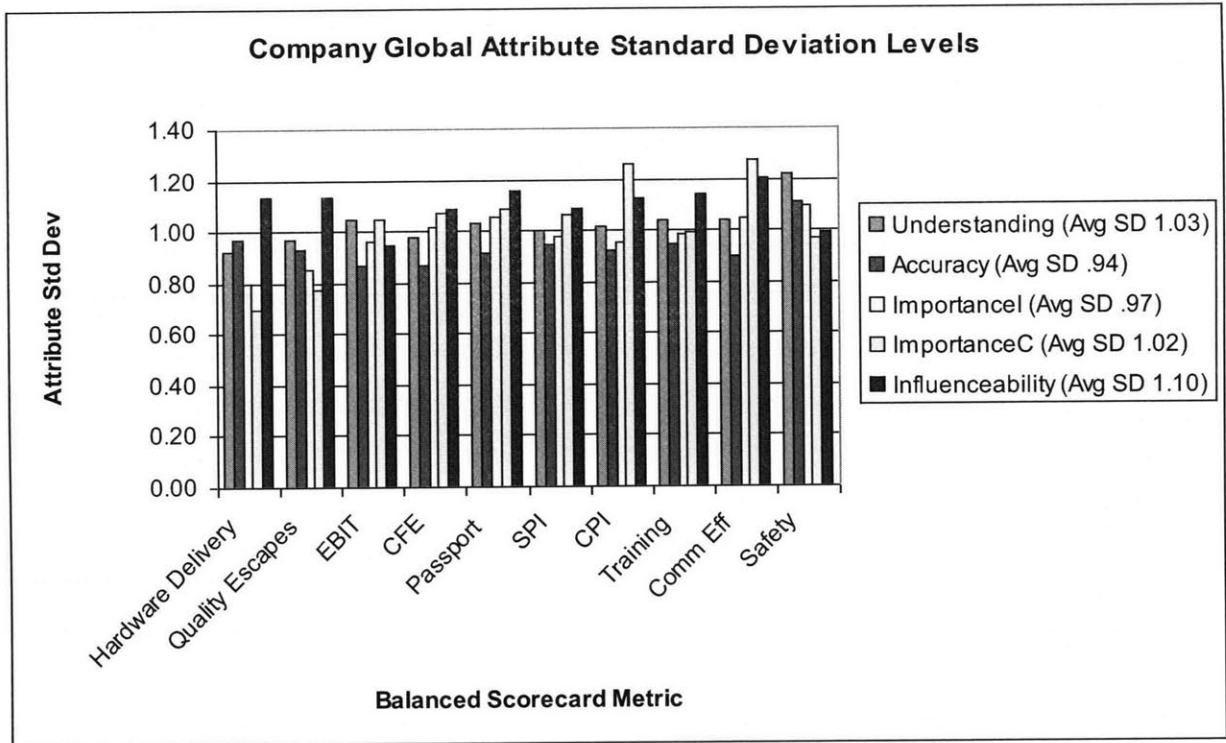


Figure 9. Standard Deviation levels for information attributes of each metric

Figures 10 and 11 show the the range of average attribute levels across employee ranks and departments. As evidenced by generally higher ranges in Figure 10 than those in Figure 11, rank appears to have a significant effect on Understandability and Influenceability, while departmental effects seem less significant. Table 8 summarizes the range data from Figures 10 and 11 for each metric, again with respect to both rank and department. Gray shading indicates the higher value for either rank or department. While this table still indicates rank has a dominant influence over department for the attributes of Understanding and Influenceability, there appears to be less rank or department bias for Accuracy, Internal Importance, and Customer Importance.

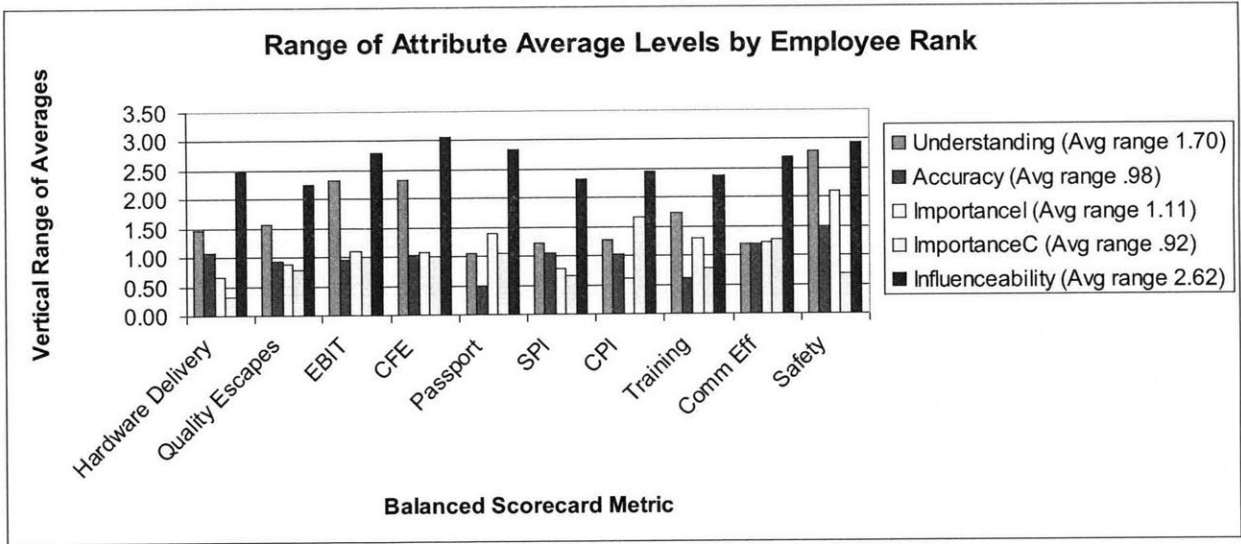


Figure 10. Rank influence on attribute communication

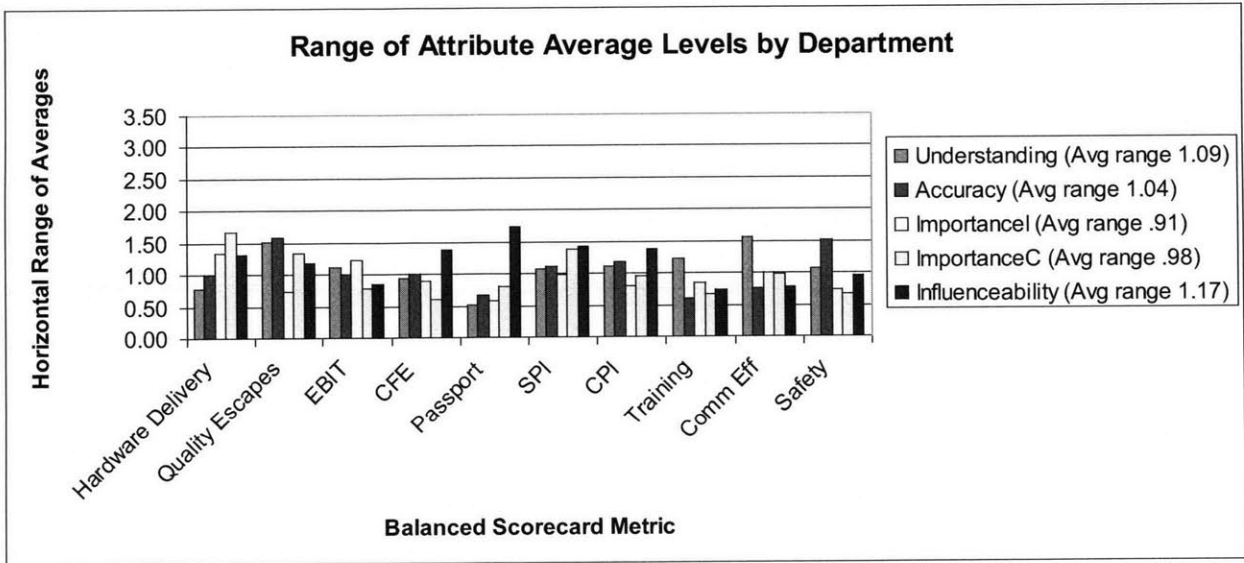


Figure 11. Departmental influence on attribute communication

RANGE OF AVERAGE ATTRIBUTE LEVELS ACROSS RANK OR DEPARTMENT										
Metric	Understanding		Accuracy		ImportanceI		ImportanceC		Influenceability	
	Rank	Department	Rank	Department	Rank	Department	Rank	Department	Rank	Department
Hardware Delivery	1.47	0.78	1.08	1.00	0.67	1.33	0.33	1.67	2.47	1.31
Quality Escapes	1.56	1.52	0.93	1.58	0.89	0.74	0.78	1.33	2.26	1.17
EBIT	2.33	1.11	0.94	1.00	1.10	1.22	1.00	0.79	2.78	0.86
CFE	2.33	0.93	1.02	1.00	1.08	0.89	1.00	0.60	3.06	1.37
Passport	1.06	0.52	0.48	0.67	1.39	0.59	1.06	0.81	2.84	1.75
SPI	1.22	1.07	1.06	1.11	0.78	0.98	0.66	1.38	2.33	1.43
CPI	1.28	1.12	1.02	1.19	0.62	0.81	1.66	0.95	2.44	1.38
Training	1.75	1.22	0.61	0.60	1.29	0.84	0.78	0.67	2.38	0.73
Comm Eff	1.19	1.56	1.19	0.77	1.21	1.01	1.28	0.98	2.69	0.78
Safety	2.80	1.07	1.50	1.51	2.10	0.73	0.68	0.67	2.93	0.96

Table 8. Rank versus Departmental Influences on Uncertainty

Table 9 presents a further comparison between rank and departmental influence by computing the differences between the rank versus department ranges. A gray shade represents a relatively strong influence, with positive values indicating a rank effect and negative values indicating a department effect. The threshold for determining “strong” influence was chosen as the standard deviation for each attribute in either the positive (rank) or negative (department) direction. Comparing this way, Influenceability becomes completely rank-dominated, Understandability less so, and the remaining attributes of Accuracy, Internal Importance, and Customer Importance appear to be metric dependent as to whether rank or department exerts a stronger influence.

Metric	DIFFERENCES BETWEEN ATTRIBUTE RANGES				
	Understanding	Accuracy	ImportanceI	ImportanceC	Influenceability
Hardware Delivery	0.69	0.08	-0.67	-1.34	1.15
Quality Escapes	0.03	-0.65	0.15	-0.56	1.08
EBIT	1.22	-0.06	-0.12	0.21	1.92
CFE	1.40	0.02	0.19	0.40	1.69
Passport	0.54	-0.19	0.80	0.24	1.09
SPI	0.15	-0.05	-0.21	-0.72	0.90
CPI	0.16	-0.17	-0.19	0.70	1.06
Training	0.53	0.01	0.45	0.12	1.64
Comm Eff	-0.37	0.43	0.20	0.30	1.91
Safety	1.73	-0.01	1.37	0.01	1.97

Table 9. Rank versus Department influence, further refined

4.2.3 Initial Interpretation of Results

Correlation Analysis

The two pairings with the highest correlation coefficients – Understanding / Accuracy, and Internal Importance / Customer Importance – have legitimate reasons for

their interdependence. With the two Importance Attributes, the link is obviously “importance” itself; metrics that have importance to the customer will naturally have importance to the internal organization, establishing a direct correlation. There are also indirect influences. Several participants in their comments stated with regard to the metric “Cost Performance” that the customer may not care on a short term basis about how well the internal company is performing on cost *as long as the customers are still getting what they want*. However, if poor cost performance puts the company out of business, the customers’ interest starts to increase significantly, thus establishing the indirect interdependence. For Understanding / Accuracy, the two are likely related because understanding a metric informs the opinion of how accurate one believes the metric to be. While this does not guarantee correlation, the fact that the metrics are posted for the entire organization to see places pressure on upper management to ensure the highest possible accuracy, and employees tend to trust in most cases that proper diligence is done for accuracy because it is simply embarrassing to be inaccurate. For this reason, a higher likelihood that employees will understand the metric would increase the level of diligence placed on accuracy.

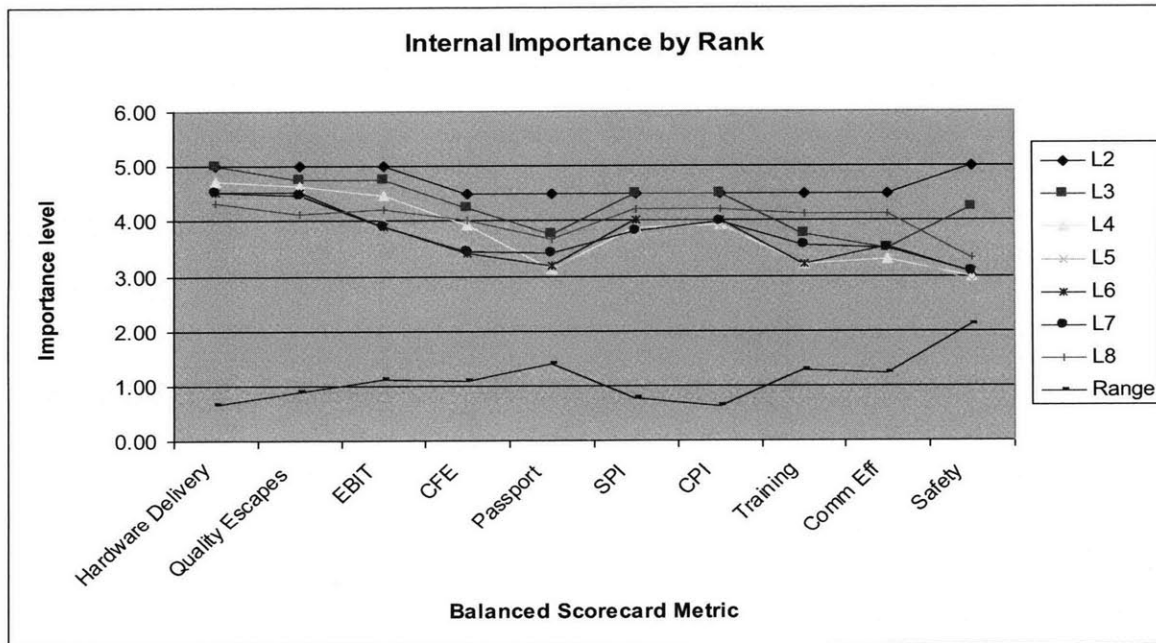
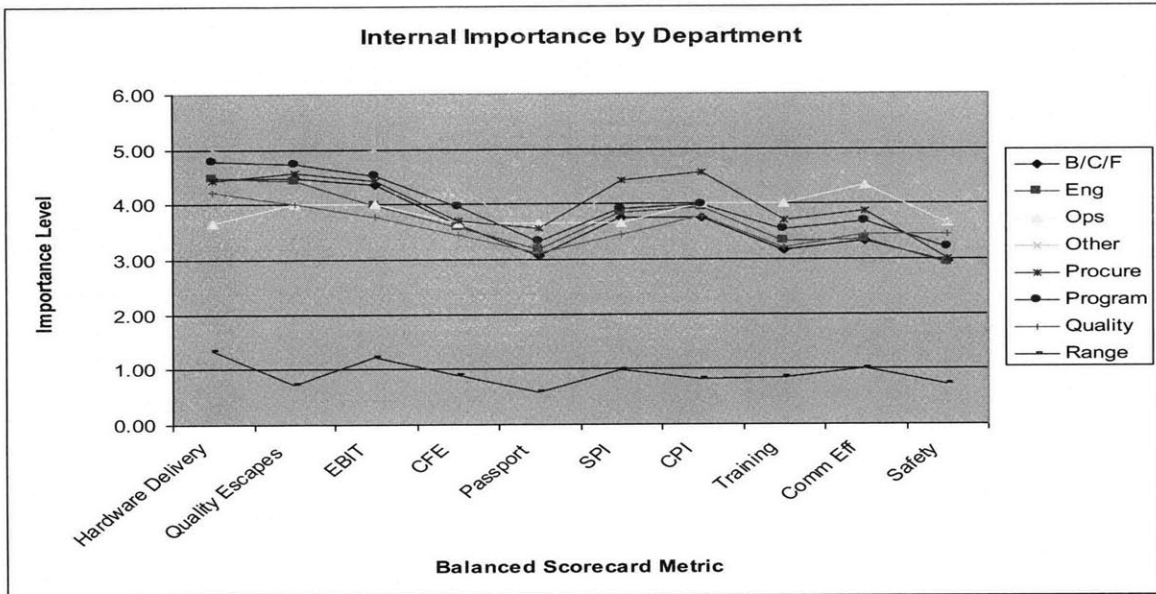
For the low – or possibly negative – correlation between Accuracy and Customer Importance, one must consider two cases. In consideration of the possibility of a negative correlation, it is not unreasonable to think that some employees may believe a metric could be falsely inflated if it is important to the customer. In this case, Accuracy belief would be lower if Customer Importance is higher. However, there is also a strong argument that the two are independent. In most cases customers are more focused on the manifestations of the metric that impact their operation – such as late parts or parts that fail due to poor quality – than they are on the metric quantity itself. For this reason, it may be argued that customers are indifferent to how accurate the internal metrics are. This would influence participants to answer in such a way that these two attributes are independent of one another rather than negatively correlated.

For either case of low or high correlation between any of the attributes, the question may be asked of what inferences may be drawn from an organizational communication standpoint. The DWS perspective does not offer much insight when simply examining the empirically derived interdependencies from a simple correlation

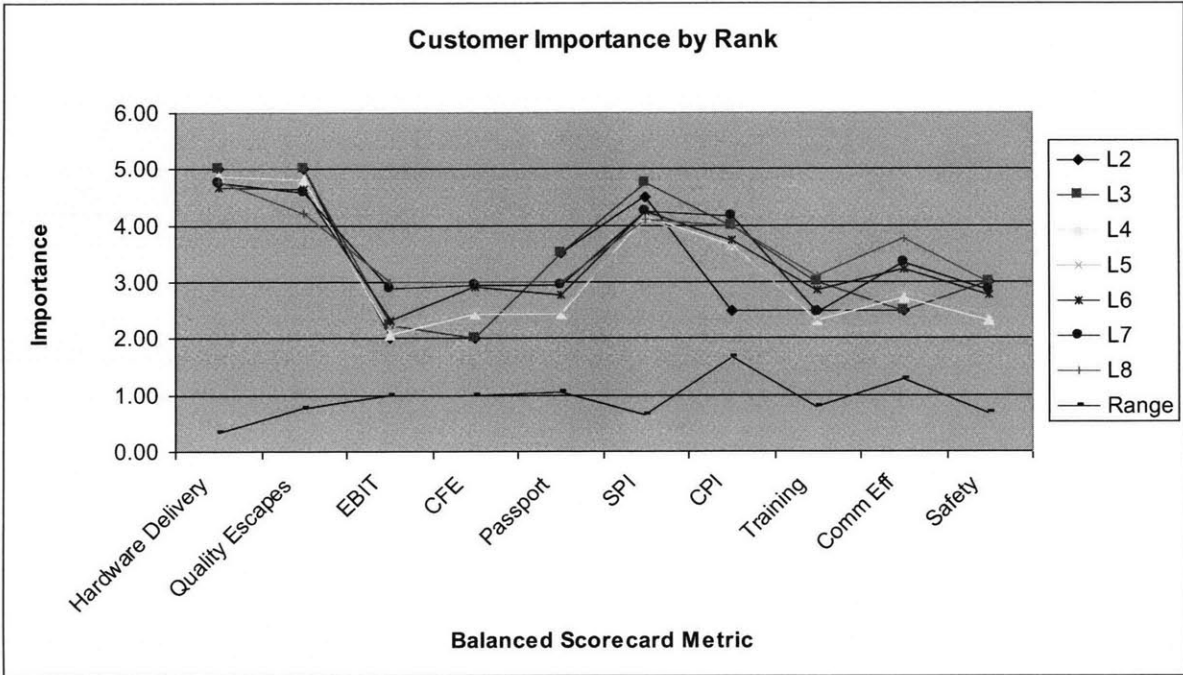
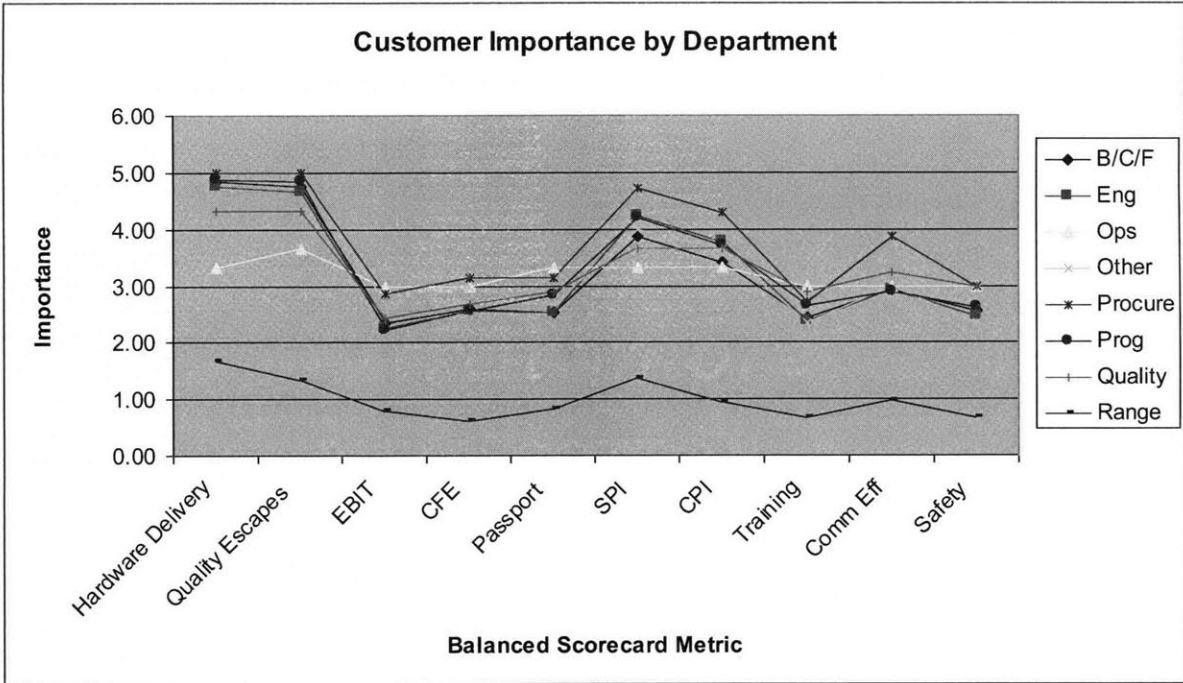
analysis. However, if leadership were trying to improve organizational communication with respect to these informational attributes, their strategy for implementing this improvement may be affected by correlation knowledge. Attributes that are independent from one another may need their own resources, while effort to improve Understanding may also reap returns on Accuracy (and vice versa) and similarly with Customer and Internal Importance. This may influence medium selection and resource allocation, two strategic considerations in the implementation of an improvement plan.

Statistical Analysis – a DWS Perspective

Aside from the obvious trends observed by direct examination, can additional insight be gained from the perspective of the DWS model parameters? First it is necessary to understand what the ranges mean. A *high* range between employee ranks implies that communication between ranks is poorer than if the range was lower. Referring back to Figure 10, Understanding and Influenceability bars dominate the “skyline” of the chart, indicating that communicating these attributes between ranks is more difficult than communicating the other attributes. Also, Figure 11 shows generally lower ranges within departments which indicates that communicating these same two attributes between departments is less difficult than communicating between ranks. From the DWS model, this implies that the attribute of λ is *generally low and typically lower than ζ* for these two attributes. Examining the same data for Accuracy, it is difficult to assess an absolute level, but it appears as though *λ and ζ are about equal to each other*. The two Importance attributes appear to be metric dependent since neither show a strong general inclination toward rank or department influences, so it is unclear what the inferences are for λ and ζ based on only this data. However, Figures 12 through 15 provide more insight into rank and departmental trends for Importance. While both Importance attributes appear to associate importance randomly among the metrics, there is a strong characteristic contained in both plots that Importance between ranks and between departments track very closely to one another. This is a very strong indicator that *the general levels of importance for each metric are communicated consistently across both ranks and departments, meaning λ and ζ are high with regard to both Internal and Customer Importance, or more generally, with regard to Importance itself*.



Figures 12 and 13. Internal Importance by Department and Rank respectively



Figures 13 and 14. Customer Importance by Department and Rank respectively.

One last general finding from the data is with special regard to Influenceability. Figure 8 illustrated an obvious trend of average Influenceability levels across the entire organization being consistently and significantly lower than the other attributes. Standard

deviation and range of average values also show the highest levels for this attribute. Conventional wisdom on matrix organizations may attribute this characteristic to employee confusion on roles or processes or both. From a DWS perspective, role ambiguity may be indicating a relatively low level of task decomposability represented inversely by the parameter ξ . This should not come as a surprise given the complexity of products and systems offered by the organization – factors which also are contributors to high task complexity and interdependency which also affect ξ - and the large size of the organization itself. Also recalling the common root cause from Davis and Lawrence’s critical evaluation of matrix management – poor management communication of roles and responsibilities to employees which implies a low value of λ – it may be expected for Influenceability to be low. This further supports that Influenceability data may be the best indicator of task decomposability within an organization, and large organizations with complex products may be expected to have low task decomposability (or high values of ξ), and may be further aggravated by low values of λ as pointed out by Davis and Lawrence’s criticism of management’s communication. Another potential explanation may simply be that the company’s policies and culture place too much risk or too little reward on personal responsibility. In this regard, if further surveys of this kind are attempted, it might be worthwhile to add a question that would allow influenceability by a group that the individual is a member of to be differentiated from purely individual influence.

4.3 Survey Comments and the “Missing Metric”

Most involved in distributing and collecting survey data will say that the most useful and interesting information is contained within the participants’ comments rather than in the quantifiable portions. The survey in this study supports that assessment to at least some degree. Comments ranged from thoughtful insights regarding particular metrics or attributes on one side of the spectrum, to “What is the [Balanced Scorecard]?” on the other end. For each attribute being measured there appeared to be at least one or more repeating themes, several of them supporting literature findings or trends observed in the data. Some attributes solicited more comments than others as Figure 15 attests, though this may be merely an effect of the order of the questions – i.e. people may have

been more likely to provide comments early in the survey than later. Seventy-eight participants volunteered suggestions or comments for metrics they felt were missing from the Scorecard. Understandability received the most comments by far, partly due probably to its placement in the survey, and possibly also from its underlying complexity.

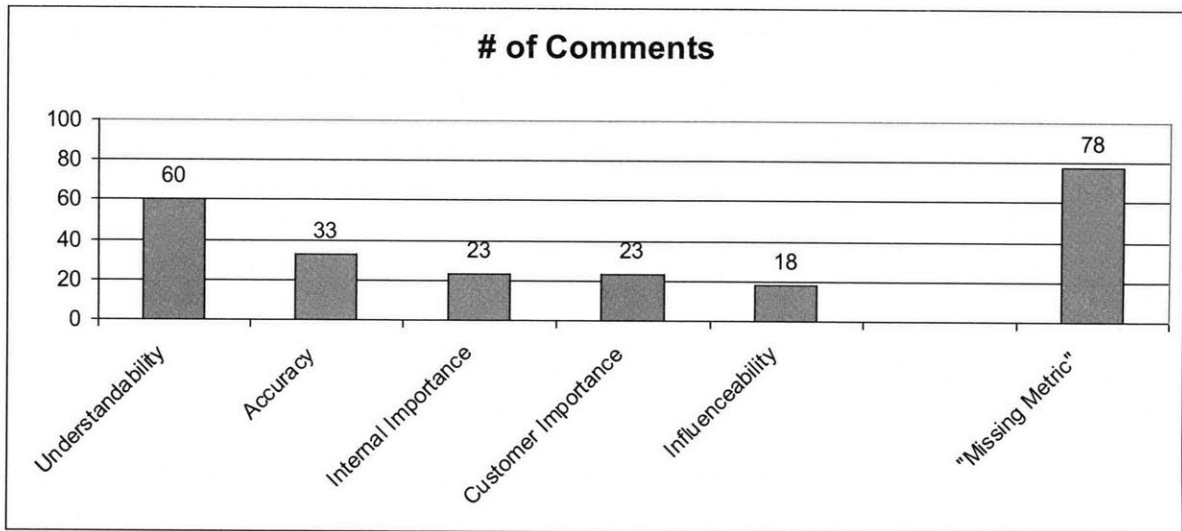


Figure 15. The number of comments received per attribute.

Appendix 3 contains a detailed summary of comments received for each attribute along with the rank and department of the employees who provided them. Quotation marks indicate a direct quote from the participant, including grammar and misspelling anomalies. Some terminology is disguised with a substitute comment inserted in brackets [...] to protect the interests of the organization under study.

A Shannon/DWS Interpretation of Survey Comments

Table 10 identifies common themes observed from the survey comments, and insights these themes may be providing to understanding the survey results in terms of the DWS model and Shannon communication theory. There were many suggestions for the “Missing Metric”, including some that said there were “too many metrics already.” Appendix D contains the summary of these comments. Many suggested adding Employee or Customer Satisfaction metrics, simply not seeing that both these metrics are contained in the upper right and left (respectively) corners of the Scorecard. This

oversight suggests possibly a Level A Shannon communication problem, that of simply not receiving the signal. More interestingly perhaps if coupled with the “too many metrics” comment, it may be possible that a human bandwidth level for this type of medium is being strained – there simply may be too much information on the Scorecard for a person to reasonably process in the expected time interval. This assessment is further supported by the fact that there were many worthy suggestions that certainly are not included – the Cost of Poor Quality (COPQ), Engineering Escapes, Inventory, Production First Pass Yield, Attrition, Innovation measures (such as new Patents per month), and several others.

Attribute	Common Theme(s)	DWS or Shannon Insight(s)
Understandability	<ul style="list-style-type: none"> - Not familiar with acronyms TRIR/LWIR and EBIT - Questions on source data and calculation techniques - Occasional department localization (i.e. Quality only understands Quality metrics well) - Suggestions to refer to department Scorecard rather than high level Scorecard 	<ul style="list-style-type: none"> - Acronym unfamiliarity is classic Level B Shannon problem. - Questions regarding source data and calculations hint at high complexity - Departmental scorecards are evidence of decomposability, in this case by customer or discipline.
Accuracy	<ul style="list-style-type: none"> - Several mid-levels suspected manipulation of metrics by management (one offered counter to this) - Some metrics considered too “subjective” - Some challenged source data and calculation method - One admitted lack of familiarity with the Scorecard citing “too busy”. - Same acronym comments as previous 	<ul style="list-style-type: none"> - Shannon’s “Noise” appears to be causing mistrust of metric quantities. Since comments directed towards “management”, suspect this noise is hindering communication between ranks. - “Too busy” comment hints that there is little utility for Scorecard information for some.
Internal Importance	<ul style="list-style-type: none"> - Several acknowledge all metrics are important, but not all well understood - Most comments metric-specific - Continuing acronym comments 	<ul style="list-style-type: none"> - Metric-specific comments reinforce quantitative assessment that all are on the same page as to priorities
Customer Importance	<ul style="list-style-type: none"> - Most comments metric-specific - Asked for clarification on “internal” versus “external” customers - Continuing acronym comments 	<ul style="list-style-type: none"> - “Internal” customers typically are managers or other departments. This suggests communication barriers on both axes.
Influenceability	<ul style="list-style-type: none"> - Items accomplished as a “team, not individually”. - Some said too much focus on making the metric rather than on improving behaviors that positively influence it - Continuing acronym comments 	<ul style="list-style-type: none"> - “Team” comment suggests different roles recognized. This hints that organization has decomposition that may not map to the tasks ideally. - Need for some to clarify influence on metric vs influence on actual performance (Scorecard’s intent) further suggests poor management communication of expectations, etc.

Table 10. High level summary and analysis of survey comments on attributes

Clearly, company leadership decided that not all metrics could be included on the Scorecard, rather only those that were currently deemed most important. Again, this suggests that a chart that is “too busy” will not be effective, indicating some subjective level of human limitation for processing data that the leadership did not want to exceed. The DWS parameter associated with this phenomenon is volatility, represented by μ , which is the measure of how many messages must be processed by an average single node in one time interval. A “busy” chart may generate values of μ that exceed individuals’ capabilities to process the high volume – a limit indicated by the DWS parameter R – which produces a higher risk for message loss due to congestion.

4.4 Deep-Dive into Program Office and Engineering Departments

Because of the high level of rank representation in the Engineering and Program Office departments, further data analysis was conducted on these two departments. Table 11 shows the side-by-side demographics. Generally speaking, Engineering headcount is larger than Program Office headcount in the overall organization by approximately the proportion seen from the table. Program Office by nature tends to be more “top-heavy” in ranks by nature of the types of positions: Program Managers, Business Analysts, Technical Lead, and Operations Leads tend to not staff at L8 entry levels and headcounts are light from L6 and below. Meanwhile, Engineering consists of the various disciplines: Project, Design, Structural Analysis, Drafting, Systems, and different specialties are all represented. Also of note, many of the Program Office staff came from Engineering backgrounds, and this also may be said of a large number of the executive leadership in the business units studied.

Engineering		Program Office	
Rank	Qty	Rank	Qty
L2	1	L2	1
L3	2	L3	1
L4	33	L4	28
L5	62	L5	5
L6	20	L6	4
L7	25	L7	3
L8	6	L8	0
Total:	149	Total:	42

Table 11. Comparison of Engineering and Program Office representation

As expected, there were some differences between the two departments regarding communication. Figures 16, 17, and 18 provides a brief synopsis of the average attribute levels of Understanding, Accuracy, and Influenceability. None of these charts make a compelling argument that one department has a general average level of Understanding, Accuracy belief, or Influenceability greater than the other. Importance attributes, shown to be largely metric dependent, could not be compared using averages, but Importance trends within these two departments were consistent with the general results.

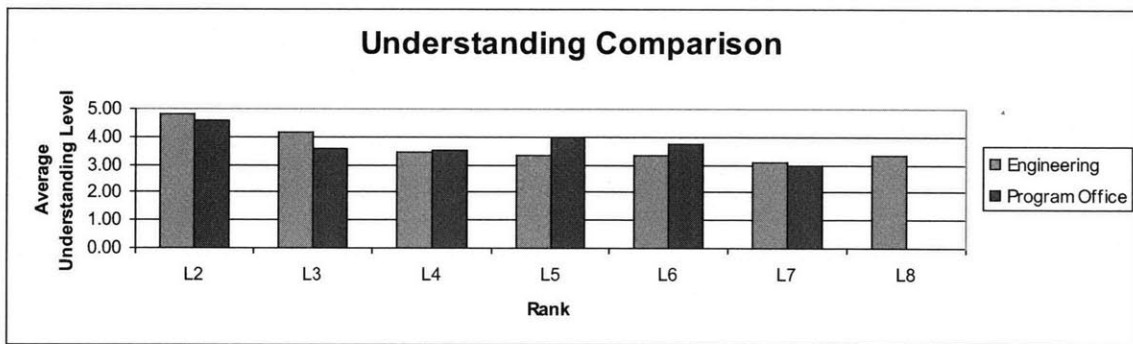


Figure 16. Comparison of Understanding Attribute

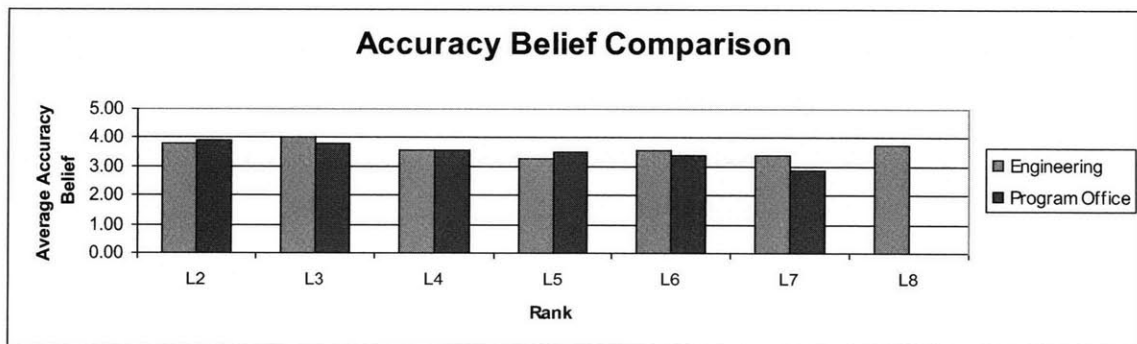


Figure 17. Comparison of Accuracy Belief

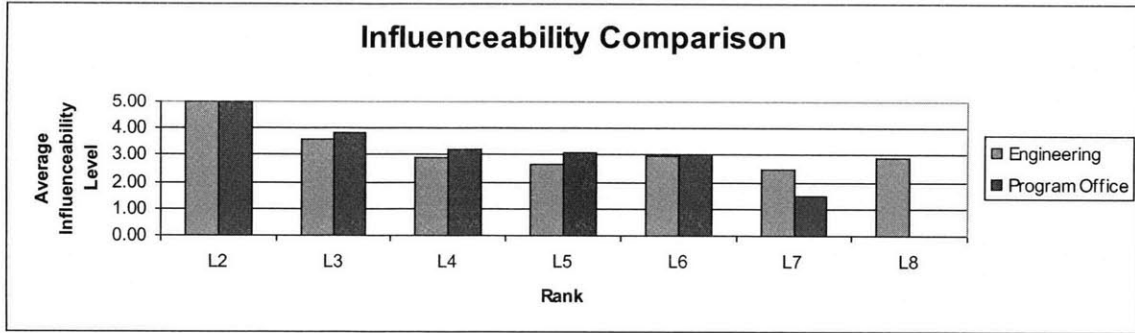


Figure 18. Comparison of Influenceability

Figures 19 and 20 contain comparisons of the attributes for each rank according to each metric. While average Understanding levels are inconclusive in the prior figures, observing Understanding across the varying metrics from Figure 19 yielded some insights. For the Engineering department, Understanding across ranks for each metric was relatively consistent across the non-executive levels (L4 and below). Figure 20 also seems to show a trend among these ranks that there is some departmental Understanding bias for the metrics of Hardware Delivery, Quality Escapes, Passport, SPI, and CPI metrics, as these metrics all exhibited relatively higher average levels of Understanding in each rank. L2 and L3 ranks not surprisingly had higher average levels of understanding across all metrics, most likely due to increased opportunity for exposure to these metrics that comes with their rank. In Figure 20, Program Office, while exhibiting similar decay in Understanding level with decreasing rank, was a bit more erratic across ranks. Though trends in Understanding were similar to those of Engineering, there was higher variance between ranks as shown by the vertical spread of the data.

Engineering Understanding

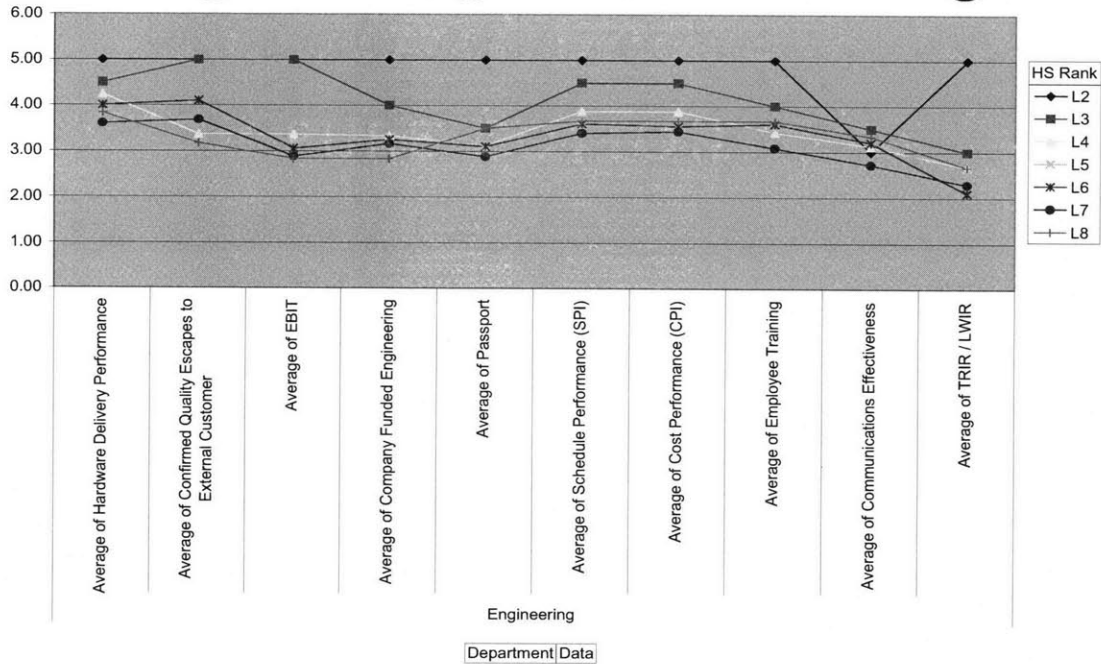


Figure 19. Understanding Trends by Rank and Metric within Engineering

Program Office Understanding

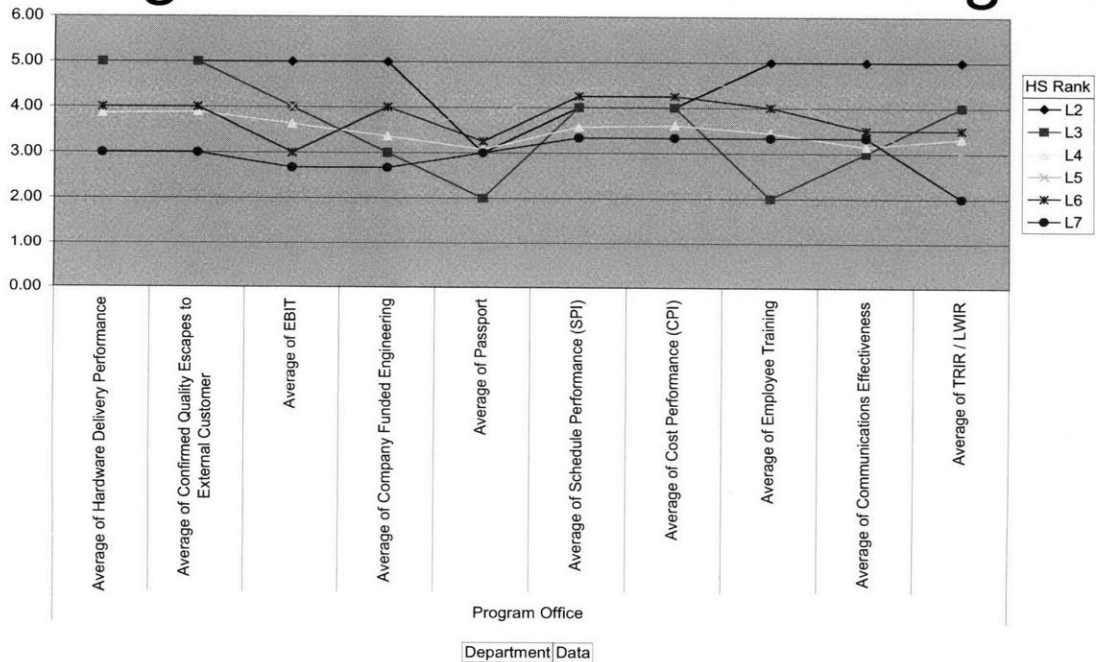


Figure 20. Understanding Trends across Rank and Metric for Program Office

Accuracy (see Appendix 5), as in the general organizational observations, did not show anything conclusive. There were no consistent trends in either department and the between-rank variance was roughly the same, with possibly slightly less in the Engineering group among L4 and below.

Influenceability between departments had high similarity in the upper ranks – as observed in Figures 21 and 22 – which was consistent with the general observed trends. Engineering again exhibited less variance between the L4 and below ranks than Program office. The strongest indicator of a rank influence for Influenceability is the large dropoff in this attribute for every metric, regardless of department, from executive levels L2 and L3 to working levels L4 and below.

Engineering Influenceability

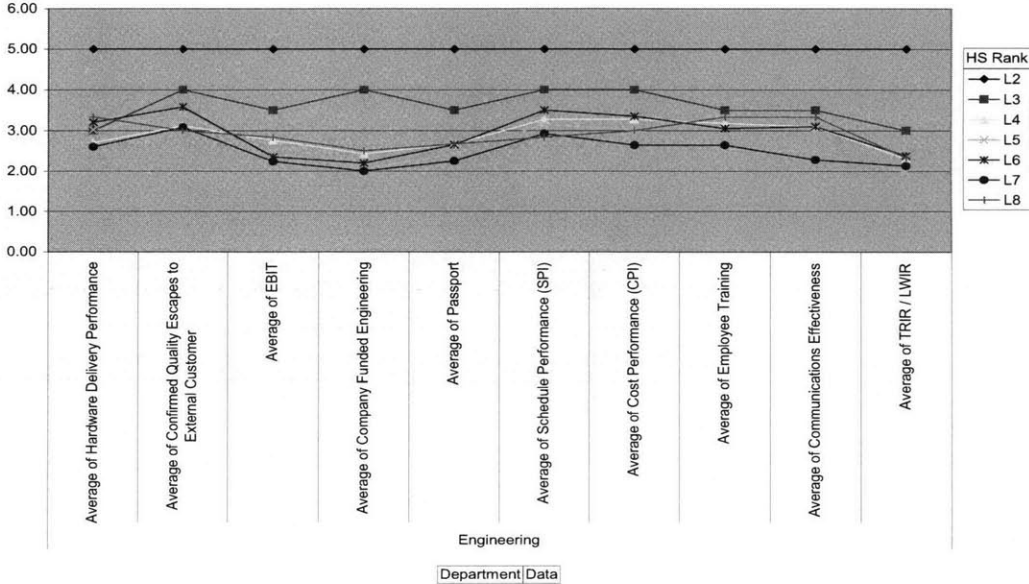


Figure 21. Influenceability Trends across Rank and Metric for Engineering

Program Office Influenceability

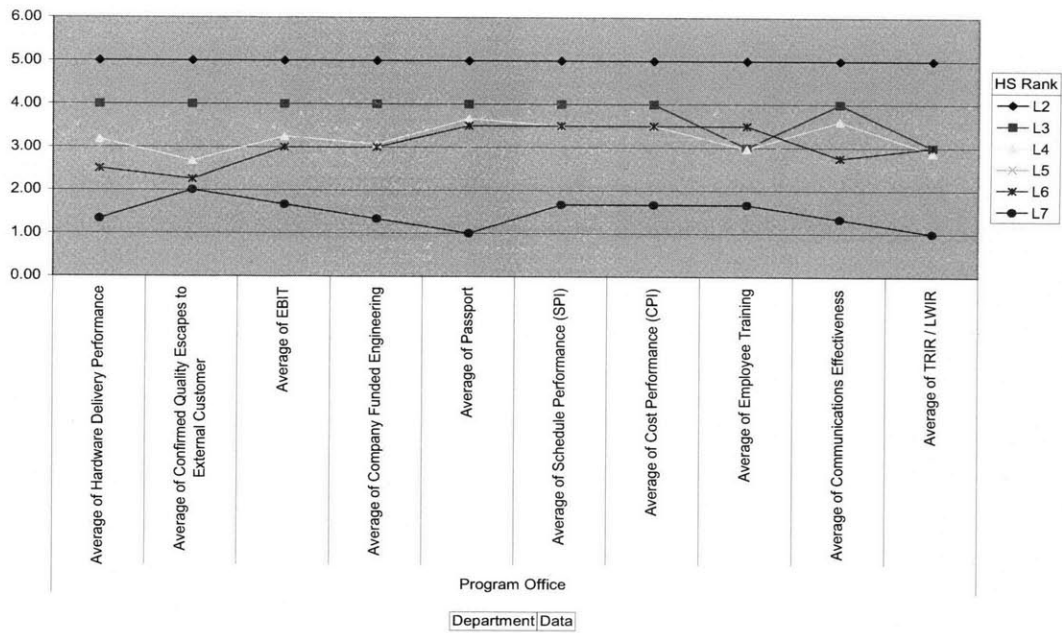


Figure 22. Influenceability Trends across Rank and Department for Program Office

Another inference gleaned from the comparisons between the two departments is made by consideration of the within-rank variance levels in Understanding and Influenceability. Figure 23 shows the average standard deviation for Understanding across all metrics for each rank L4 and below (excluding L8 since there are zero in Program Office). The working level ranks (L4 and below) in the Engineering department exhibit consistently higher within-rank variance than the Program Office, especially for L5 and below. Figure 24 shows a similar trend for these same ranks for Influenceability – the differences in variance are less significant, but Program Office still exhibits lower variance for each of these ranks.

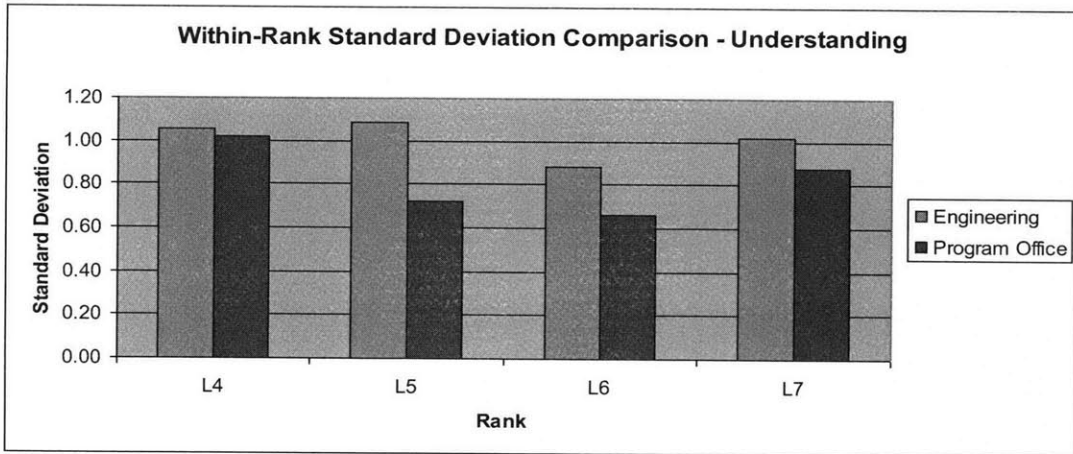


Figure 23. Average Standard Deviation Levels for Understandings

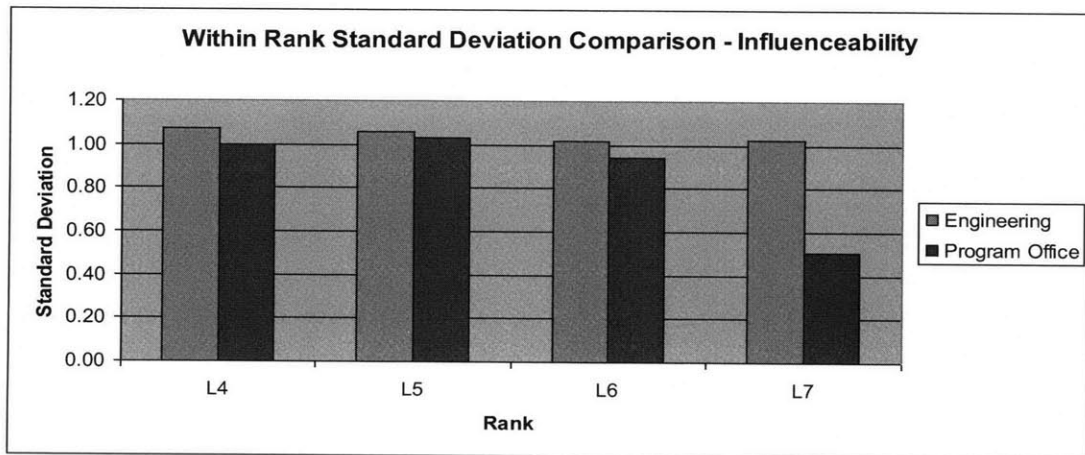


Figure 24. Standard Deviation Comparison for Influenceability

DWS Interpretation of Deep-Dive Results

Program Office shows considerably lower variance within the same ranks than Engineering, indicating that lateral communication may be superior within the Program Office department. Figure 24 makes the same comparison for Influenceability. Again, within-rank variance of this attribute is lower for Program Office than for Engineering, though to less a degree than for Understanding. Appendix 6 charts the comparison of Understanding and Influenceability for each metric. Though some metrics exhibited spikes in variance for some ranks, these appeared to be random. Reasons as to why one department shows relative strength in vertical communication (Engineering – higher λ as indicated by the tighter clustering of L4 and below levels) while the other appears

stronger in lateral communication (Program Office – higher ζ as supported by the above discussion) cannot be derived from the quantitative survey data. Another explanation is that the program office is heavily involved in matrix management activities whereas engineering is a bit less so (for the average employee) so that lateral communication is more of a norm in program management>

4.5 Post-survey Employee Interviews.

Over a month after the survey was completed, several interviews were held with employees of different rank and department. Some of the interviews were very brief and informal, and a few were more formal and had more time for open discussion. Those interviewed were a Level 2 Engineering Vice President, a senior Level 4 Program manager, a Level 6 Engineer, a Level 4 Contracts manager, and a Level 3 Engineering Director. First, I shared some of the findings of the survey and asked for their comments on the following: that Understanding increased with higher rank; that Influenceability ranked consistently lower than the other attributes; that there didn't appear to be strong departmental expertise effects on Understanding; and that Importance was communicated very well across both Rank and Department. Following this discussion if time permitted I asked them some specific questions about the Balanced Scorecard and about the quality of communication both within and between their respective departments, and about the general quality level of communication within the business unit. Their collective responses are contained in Table 12 on the following page.

Most of the comments received corroborated the survey results. The comment on the influence of “personal stake” in Understanding is interesting in that it establishes a link between accountability – which could be interpreted as roles – and this attribute. As these metrics are rolled up on a business unit level, a lower ranking employee's role will have less influence on the overall result, which this person felt would affect his or her motivation to better understand the metric. This comment makes logical sense, but the correlation data between Understanding and Influenceability does not strongly support the statement because Influenceability correlations with Understanding and all the other attributes were consistently below the average level. Further on the subject of Influenceability, the comment regarding departmental influence on specific metrics is

<i>On Understanding decreasing with lower rank...</i>
- "... not surprising since higher ranks typically have more experience." - "... experience may be an influence, but personal stake is definitely an influence on Understanding. Higher ranks typically have more personal stake in the metrics than lower ranks."
<i>On Influenceability ranking consistently low...</i>
- "I suspect each department has high Influenceability on one or two particular metrics, but relatively low Influenceability on the rest, and this drives the average levels down." - "All of us have the ability to highly influence all the metrics. When we all realize that our performance will dramatically improve."
<i>On apparent lack of influence of departmental expertise on Understanding...</i>
- "Most metrics are a cumulative result of many departments efforts... wouldn't expect a single department to have that much more expertise, except for maybe Financial metrics ..."
<i>On how well Importance is apparently communicated...</i>
- "It's good that everybody tracks closely, but I'm disappointed because you really hope to see <i>all</i> the metrics having high Importance..." - "... we talk about the important metrics in most of our meetings..."
<i>On the effectiveness and efficiency of the Balanced Scorecard...</i>
It is GOOD because: - "...the metrics help the organization recognize when it needs to take action..." - "...a powerful tool; very effective; I use it all the time..." - "...having all the details on one page makes it very efficient..." - "...focuses quickly on important items..." <i>BUT:</i> - "...people at lower levels can't relate to some of it; especially EBIT..." - "...can't get all the metrics I want to see on there..." - "...gradations are only silver, gold, and bronze for current states when trends are more helpful for some metrics..." - "...our program and department level scorecards are effective, but the business unit level scorecard not as much..." - "...often can't tell what activities drive the metrics..."
<i>On the quality of communication within and between departments...</i>
- "...[in my department on the program I work on] I think we communicate very well, maybe because we all sit together. I don't really know what or how [my peers in other programs in my department] are doing, but I'd be interested to know..." - "...some communications [on process improvement initiatives] come too frequently and the format is hard to read. These tend to not be very effective for me..." - "...I think as an overall business we communicate pretty well, maybe better than most..." - "...internal content is important, but I also like the weekly newsletter that tells about the big picture and what's going on outside my program and department..." - "...I think we're generally on the same page within the business unit, but communication <i>between</i> business units could be a lot better..."

Table 12. Anecdotal information from interviews.

consistent with data observed from the Engineering and Program Office deep-dive, but it does not explain the *general* low levels of Influenceability seen across every department. The comment would support a claim of high task decomposability (or low value of ξ), but the data implies the opposite. Additionally the comment that metrics are a

cumulative result of several departments' efforts would also imply a lower decomposability, at least with regard to the interdependent tasks that produce the metrics themselves. The comments on importance also have an undercurrent: while it is true that all the metrics are very important to the business, the strong biases toward some particular metrics probably illustrates a cultural effect that the scorecard is apparently exerting little influence upon. Granted there could have been confusion among participants between "current priority" and "importance", but the data is universal enough across both rank and department to make a strong case for the cultural factor. "What we talk about in meetings" – not necessarily what is on the Scorecard – is the best indicator of the "corporate value system", also synonymous with "culture."

DWS Insights from Employee Interviews

Most interviewees thought communication within the business unit was relatively good, and not unexpectedly they thought communication between business units or different departments could improve. The effect of co-location on communication is made obvious with the one comment that communication between different program teams *within the same department* was not as good because they didn't sit with that group. Finally there are clues as to communication quantity/volatility (μ) and human bandwidth limits from the comment about too-frequent messages on process improvement initiatives.

4.6 Congestion Centrality and Volatility: A Brief Email Volume Study

To gain some additional insight into "typical" message volatility within the organization, a few more employees of various rank and department were polled with the following questions about their email:

- 1) How many emails do you receive on a typical day?
- 2) Of these, what percentage of them do you actually "process" each day? (Note: to "process" means to have read and made some decision about the email.)
- 3) Of the messages not processed, how many of these get "dropped"? (Note: to "drop" means to have never read the email. An employee may not process an

email the same day, but may catch up on emails at a later date, hence not “dropping” all the ones he didn’t address on the same day.)

Employee ID	Rank	Department	Average # emails received	% processed	% dropped
1	L2	Engineering	150	99%	0%
2	L4	Prog Office	65	50%	20%
3	L4	Prog Office	150	99%	1%
4	L4	Contracts	40	50%	"some"
5	L4	Engineering	30	99%	0%
6	L4	Engineering	90	75%	15%
7	L5	Engineering	55	85%	10%
8	L5	Program Office	25	75%	0%
9	L6	Engineering	75	75%	"some"
10	L6	Engineering	25	80%	20%
11	L6	Engineering	50	50%	"some"
12	L7	Contracts	20	99%	0%

Table 13. Results of email volume poll

Table 13 shows the answers received along with the demographics of the employees asked. Though the sample is too small to draw general conclusions, some inferences may be gathered. The first is that there are certainly centrality points in the network as evidenced by the very high email volume through some employees. The next is that human bandwidth varies highly from employee to employee, and some employees also commented that email volume varies considerably from day to day. Last is that most acknowledged at least some drops, indicating not all messages are being processed that should be. There is insufficient data to conclude whether rank and department are predictors of centrality or bandwidth capabilities, though it hints that higher ranks may see higher message flow volume. If this hint was found to be generally true, then the network begins to take on the form of the DWS Multi-scale network, making a non-trivial assumption that email traffic volume is an effective predictor of overall message traffic.

5.0 CONCLUSIONS

It is certainly possible to gain some real understanding of an organization's communication patterns by focusing on a common visibility point – in this case the Balanced Scorecard – and gathering individual employee data regarding their personal levels of the attributes of Understanding, Accuracy, Importance, and Influenceability on the information presented at this visible point. Some of these attributes exhibit a relatively strong interdependence, especially Understanding and Accuracy as indicated by a simple correlation analysis. Others appear to be independent or possibly negatively correlated, and these interdependencies should be considered by management in the implementation of a communication strategy. For the organization under study, employee rank appears to impose a more significant barrier to communication of the information attributes of Understanding and Influenceability, particularly so with Influenceability. However, the general attribute of Importance appears to travel easily across both ranks and departments. An in-depth comparison of the Engineering and Program Office departments showed the Engineering department communicating better between ranks, especially among the “working level” ranks, while the Program Office exhibited better lateral communication as evidenced by lower within-rank variance of attribute Understanding and Influenceability attribute levels. Finally, employee interviews and a brief email traffic study illustrated the effects of co-location and human bandwidth limitations as well as the natural emergence of congestion points within the employee communication network.

From the perspective of the network model developed by Dodds, Watts, and Sabel, clues as to the relative values of the parameters dictating the network's behavior can also be gained. In most cases it is impossible to determine the absolute content of a given message, but examining the range of averages – measured as either the variance within a department or rank, or as the range of average levels across departments or ranks – can provide clues as to how a message transforms between rank and department boundaries. Table 14 summarizes the general findings of the survey for each attribute and maps them into a DWS context. Appendix 2 provides further detail of attribute trends across ranks and departments.

Informational Attribute	Survey Findings	Survey Implications on DWS Parameters	DWS Interpretations and Rationale
Understandability	Considerable rank influence; low to moderate departmental influence; interdependence with Accuracy	λ – low ζ – medium ξ – high	Understandability levels decrease with rank but show little departmental influence. The complexity of this attribute is high, departmental expertise appears to have little influence, and comments about results being a “team effort” imply decomposability is low.
Accuracy	High Correlation with Understandability; no observable rank or departmental influence	λ – same as ζ ζ – same as λ ξ – insufficient data	Accuracy appeared to be indifferent to rank or departmental influences. Difficult to ascertain absolute levels; would suspect values track uncertainty; Accuracy may have lower complexity than Understandability, but data is insufficient for an assessment on decomposability.
Internal Importance	High Correlation with Customer Importance; few rank or departmental barriers	λ – high ζ – high ξ – low	Levels are metric driven and appear to be insensitive to rank or department influence. Metric levels track closely across ranks and departments, implying effective communication of attribute. Attribute is also uni-axial, so decomposability is high.
Customer Importance	High Correlation with Customer Importance; few rank or departmental barriers	λ – high ζ – high ξ – low	Same comments as for Internal Importance.
Influenceability	Highest Rank Influence (barrier); moderate departmental influence; low correlation with other attributes	λ – low ζ – medium ξ – medium	Influenceability appears to have high rank influence and some evidence of departmental expertise. Decomposability suspected to be low from Davis and Lawrence findings, but evidence of departmental expertise or ownership hint at better decomposability.

Table 14. Summary of survey data implications on DWS model parameters.

Further, it is possible to gain insight into message traffic volume and potential congestion points by examining traffic flows in particular information media. Email provides a good opportunity to observe this behavior since it is easily documented. The brief email poll conducted in this research indicates widely varying traffic flows, as well as equally varying capabilities of individuals to process this flow, a factor referred to as human bandwidth. However, it should be noted that email only partially represents the total information traffic, as there are many other types of information media available to employees.

Figure 25 presents one possible interpretation of how each of the informational attributes measured appears to be communicated within the large matrix managed aerospace organization based on the information from Table 14.

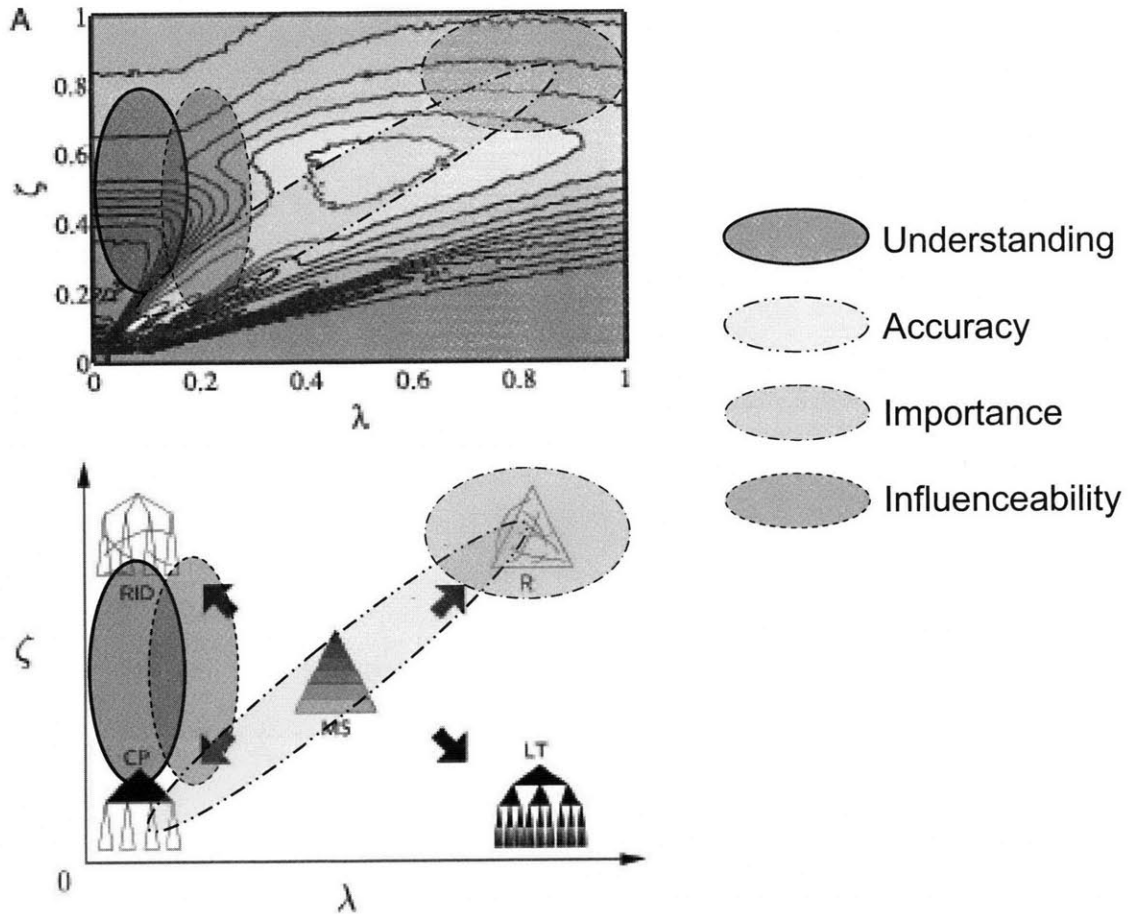


Figure 25. Assumed network characteristics of organization.

Although these plots are interesting, they are only conceptually accurate. For example, the DWS attributes were relative assessments – we cannot be sure of absolute positions of the ovals on the charts because the assessments on the DWS parameters are relative, and the scale of the x and y axes is uncertain. However the positions of the ovals relative to one another can be presented with more confidence given the information was derived from the same sample of participants. One must also pay heed to the comments from interviewees regarding their general feelings on the quality of communication within the company. Most said they thought it was “pretty good” – implying a cluster of ovals more in the center of the graph – and one highlighted the effects of co-location – implying ovals clustering in the lower right quadrant of the graph with high communication taking place within geographic clusters, in this case dictated by which program each team was working on. Finally, deeper analysis into the characteristics within the Engineering and

Program Office departments indicated that each department's culture has an influence on the flow of information up and down the ranks and flow across members of the same rank, and that these intra-departmental effects are being watered down in the overall assessment.

The Balanced Scorecard was an excellent focal point for the purposes of this research. Based on the comments, employees seemed to have a wide range of opinions about its general utility – positive, negative, and indifferent – that provided enough variation in data to draw at least some conclusions about the significance of trends observed. The scorecard appears to be an effective tool that can provide fast guidance into problem areas within the organization. However, it doesn't tell employees the nature of the problems, just the effects, and the high number of tasks and their interdependencies (i.e. their non-decomposability) present problems in how they interpret their roles toward addressing the issues the scorecard presents. This is consistent with general assertions made in past literature regarding problems with matrix management and shortfalls of the Balanced Scorecard. In the end, conclusions from this research and prior research may have already been predicted – if not exactly measured – by Shannon in his mathematical theory of communication. High-entropy attributes such as Understanding and Influenceability are more problematic than low-entropy attributes such as Importance.

Recommendations for continuing research in this subject matter would have to include studies of measurable information traffic flow across ranks and departments. It should include all types of communication media, and it must try to capture as many different organizational cultures as possible (i.e. multiple businesses in multiple industries). A better empirical understanding of the traffic flow would probably provide a better assessment of an organization's "type" with regard to the categories of DWS networks. This information could then be coupled with the data observed from conducting the same Balanced Scorecard survey in these organizations, so that more a more absolute assessment of DWS parameters could be gleaned from the empirical data.

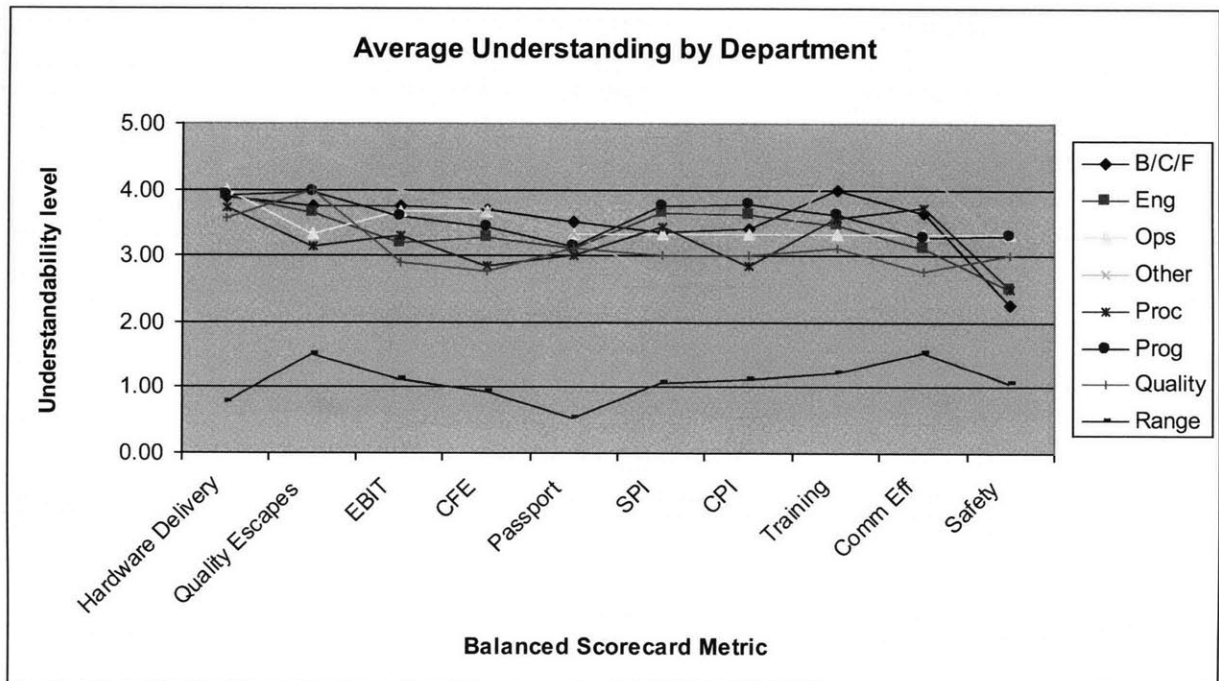
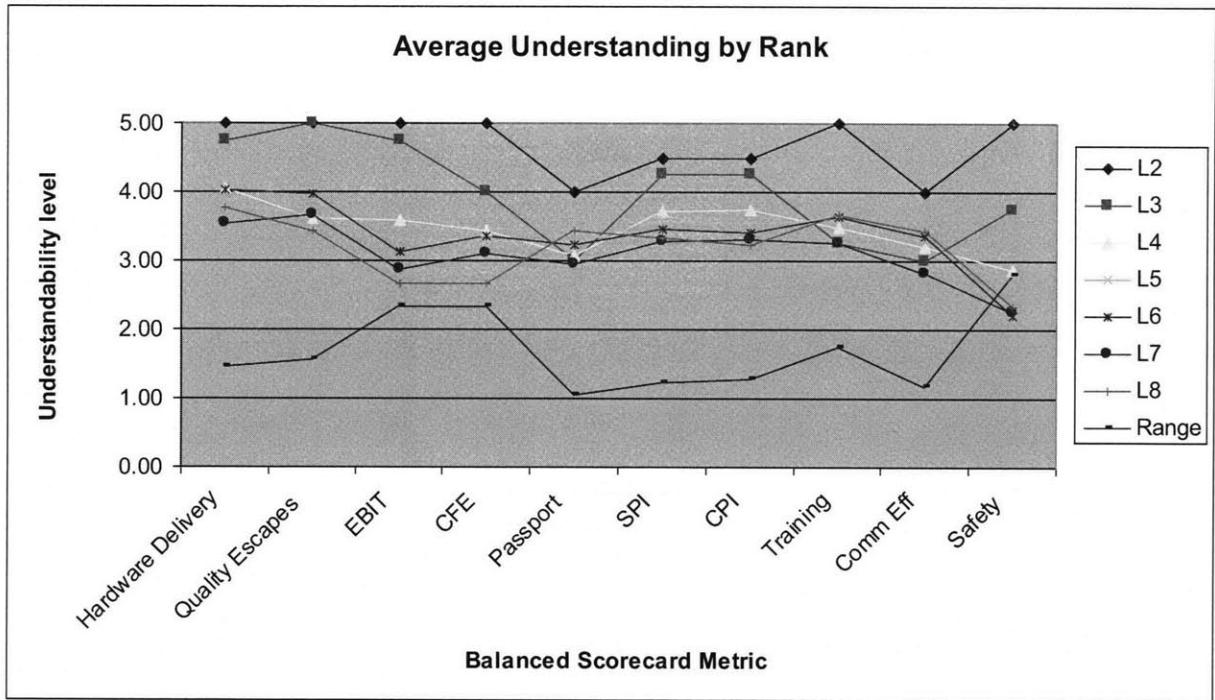
APPENDICES

2009 [Company Balanced Scorecard]													
2008 Annual Cust. Sat. Survey (Oct '08)													
Goal: 5.0 or more		Engine Systems Results		5.2		Overall		5.0		Quality		4.6	
Delivery		Relationship		5.7		Responsiveness		5.4					
Color Key: Gold Level Performance Silver Level Performance Below Silver Level Performance													
Annual Employee Survey (May '08)													
Goal: 67%		2008		Results		69%							
Certification Progression													
Site Goal for Gold: tbd													
Site Goal: Silver 4Q08													
Previous: 4Q03-2Q06													
Current Level: Bronze													
3Q02-4Q03, 2Q08													
3Q08													
Customer Value & Satisfaction			Business (Financial) Performance				Process, Product & Service Excellence			Leadership, Culture & Environment			
METRIC	Delivery Performance	Confirmed Escapes to External Customer		EBIT	Company Funded Eng'g	Passport	Program Schedule Performance (YTD)	Program Cost Performance (YTD)	Employee Training	Communications Effectiveness	TRIR / LWIR		
		Significant	Other										
Business Plan	90% or greater	Monthly Goal equal to or greater than % shown	11 or less	77 or less	100% or more of year to date plan	100% or less to YTD target	90% or more successfully completed with timing compliant to standard work	SPI of 0.95 or greater	CPI of 0.95 or greater	90% Business Need or greater	90% or greater each month	0.00/0.00 YTD	
2008 YE	89%	n/a	17	109	20%	n/a	98%	0.93	1.21	n/a	99%	0.00/0.00	
Jan-2009	90%	90%	3	7	100%	100%	100%	0.93	1.21	100%	100%	0.00/0.00	
Feb-2009	89%	90%	1	6	76%	100%	100%	0.96	1.25	100%	96%	0.00/0.00	
Mar-2009	90%	91%	0	5	100%	84%	100%	1.06	0.97	100%	93%	0.00/0.00	
Apr-2009	91%	92%	0	7	100%	69%	100%	1.06	0.95	100%		0.00/0.00	
May-2009		92%											
Jun-2009		93%											
Jul-2009		94%											
Aug-2009		94%											
Sep-2009		95%											
Oct-2009		95%											
Nov-2009		95%											
Dec-2009		95%											
2009 YTD	90%	n/a	4	25	100%	69%	100%	1.06	0.95	100%	98%	0.00/0.00	
GOLD	100%	n/a	sustain 12 mos	sustain 12 mos	sustain 12 mos	sustain 12 mos	sustain 12 mos	1.0	1.0	100% or greater	95% or greater	0.00/0.00	
METRIC PROVIDER	not shown		not shown		not shown		not shown		not shown		not shown		
METRIC OWNER	not shown		not shown		not shown		not shown		not shown		not shown		

APPENDIX 1. The Organization's Balanced Scorecard

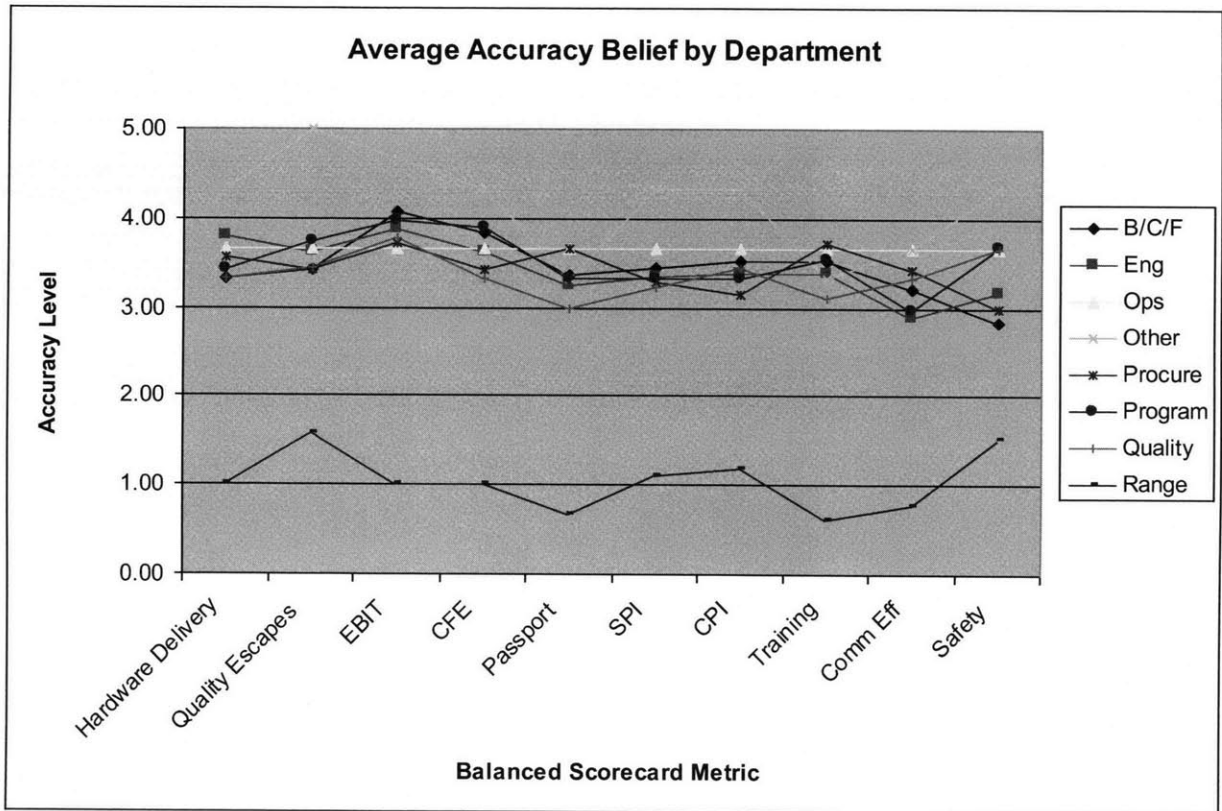
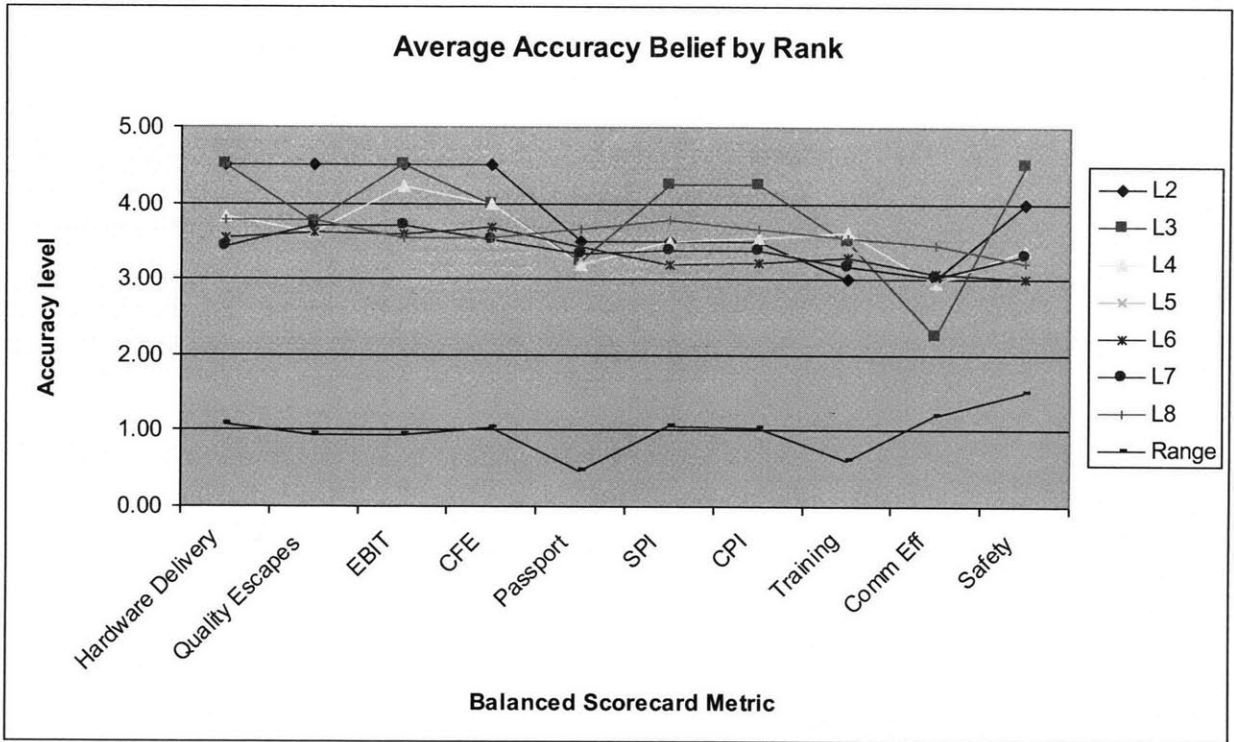
APPENDIX 2. Attribute Trends Across Rank and Department

Understanding



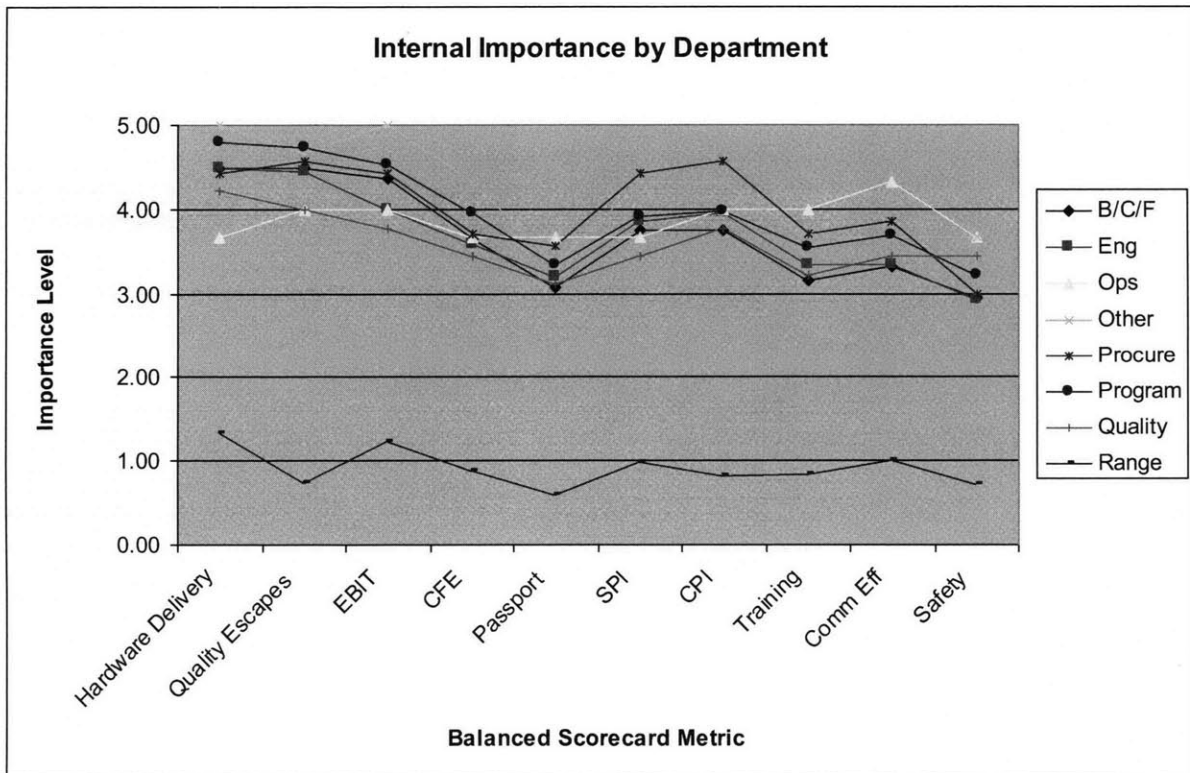
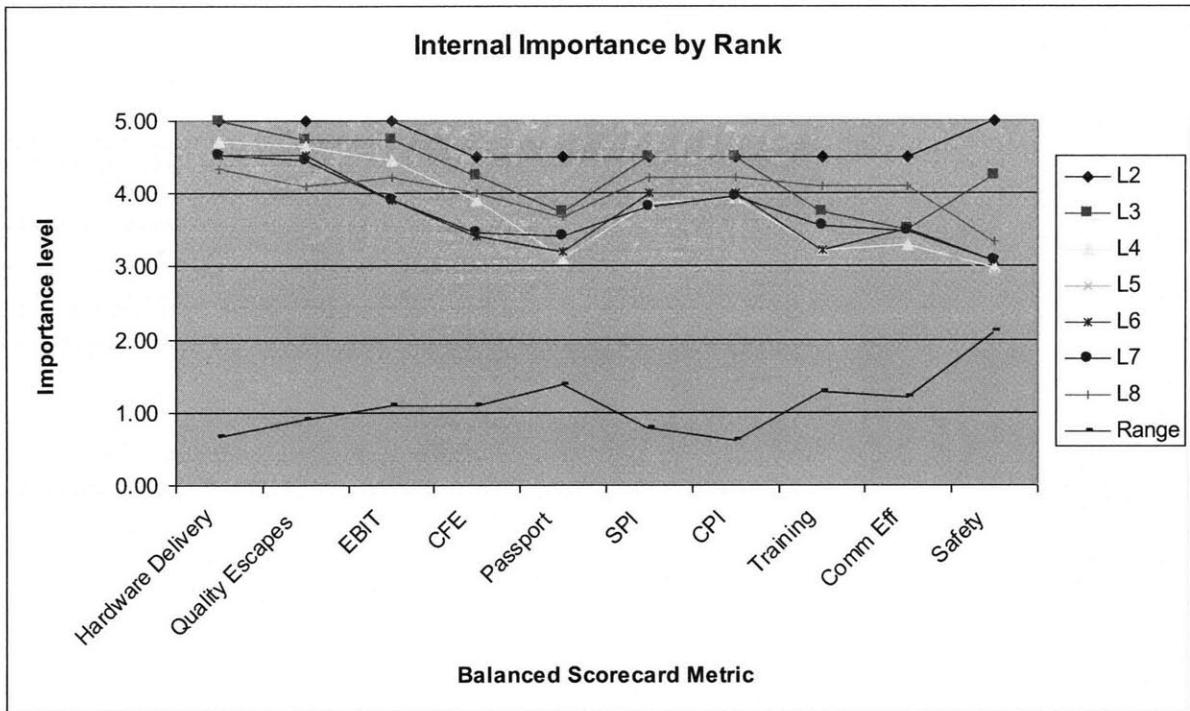
APPENDIX 2. Continued

Accuracy



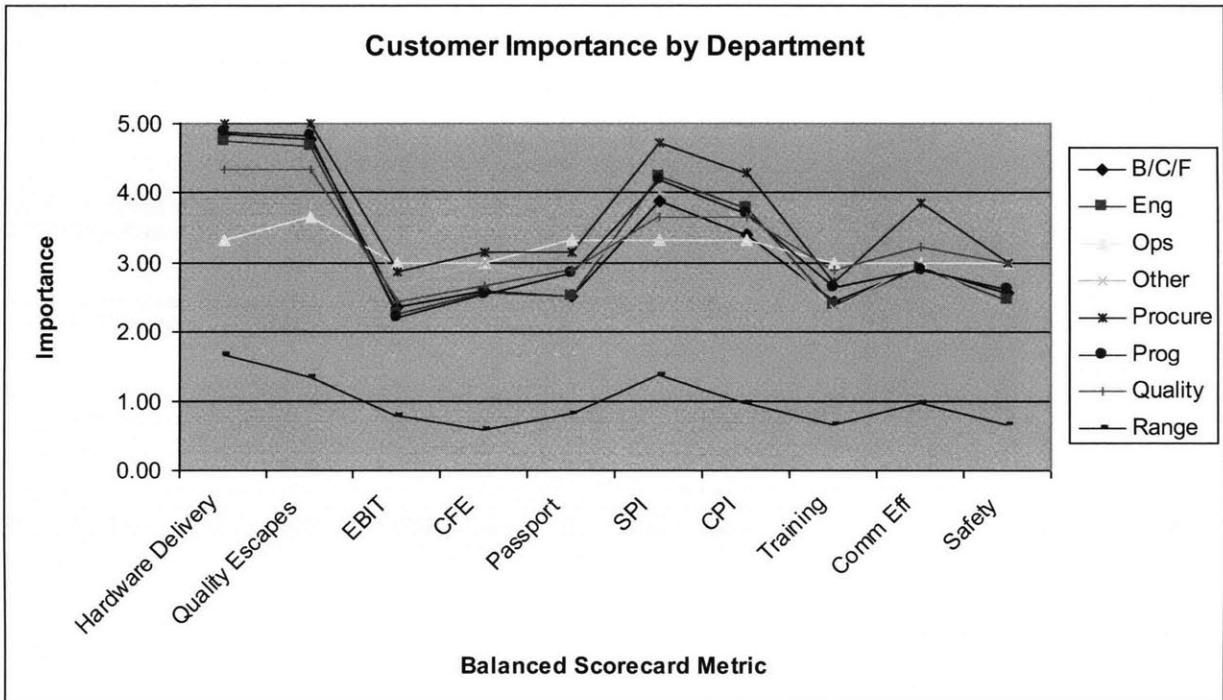
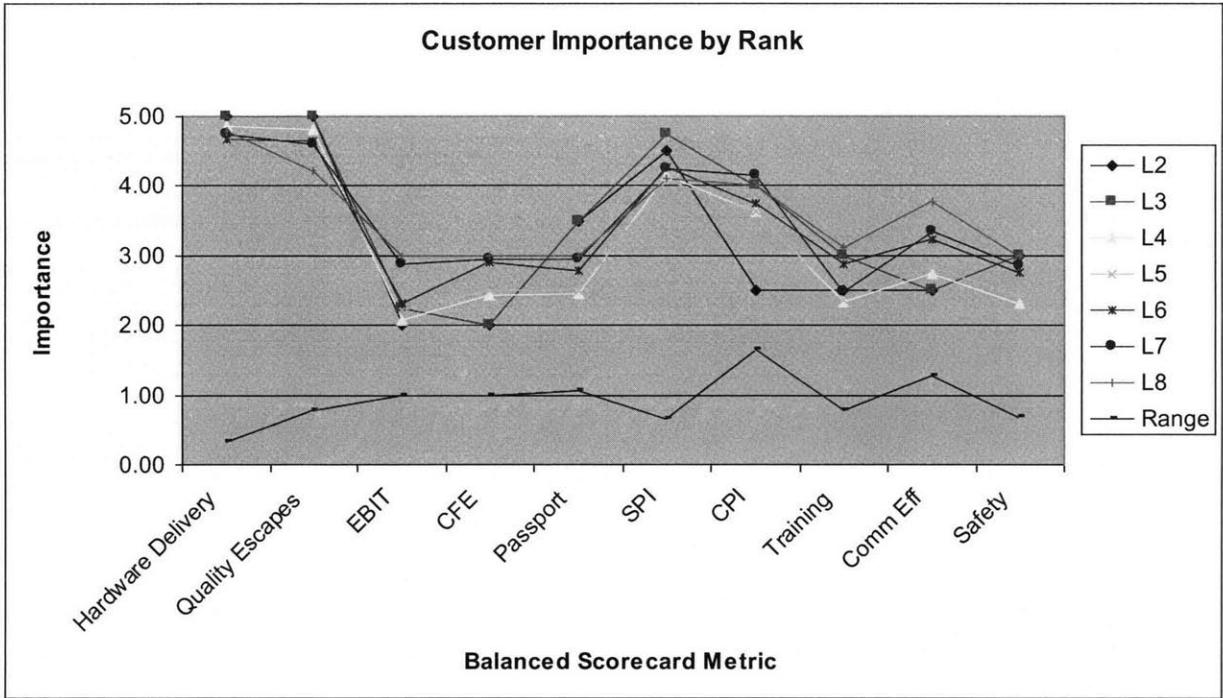
APPENDIX 2. Continued

Internal Importance



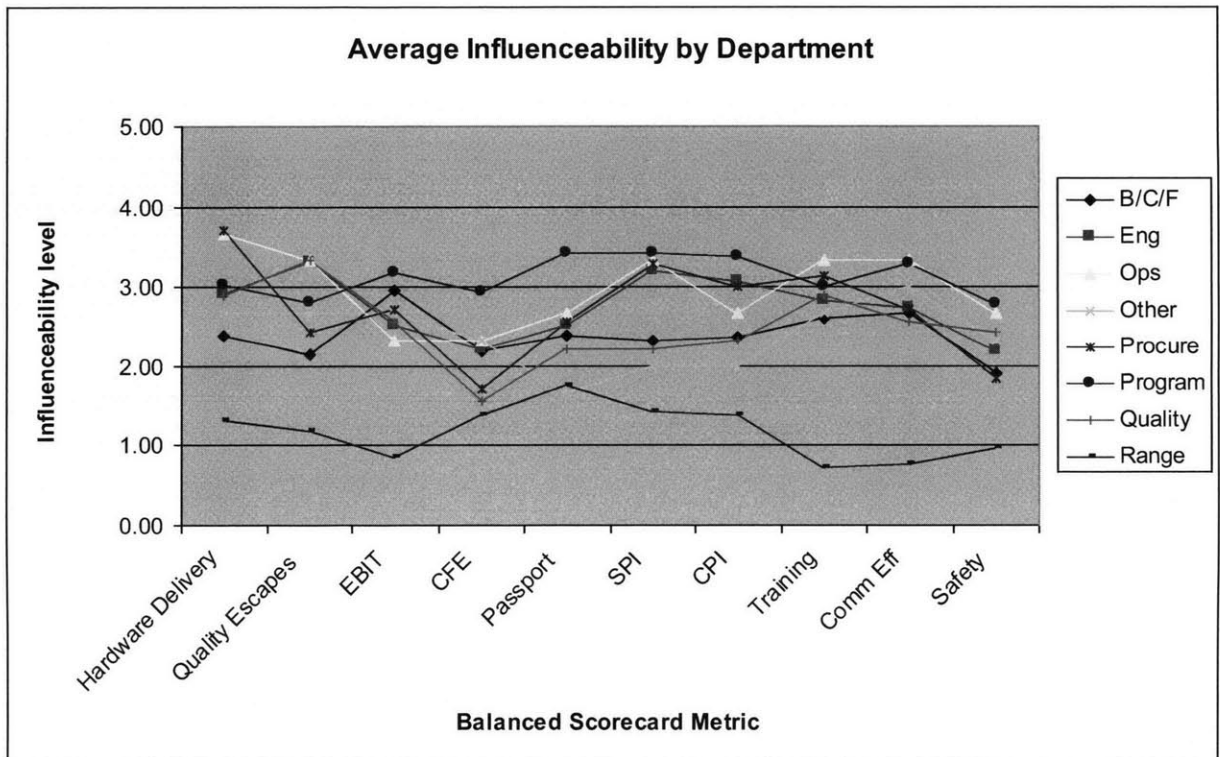
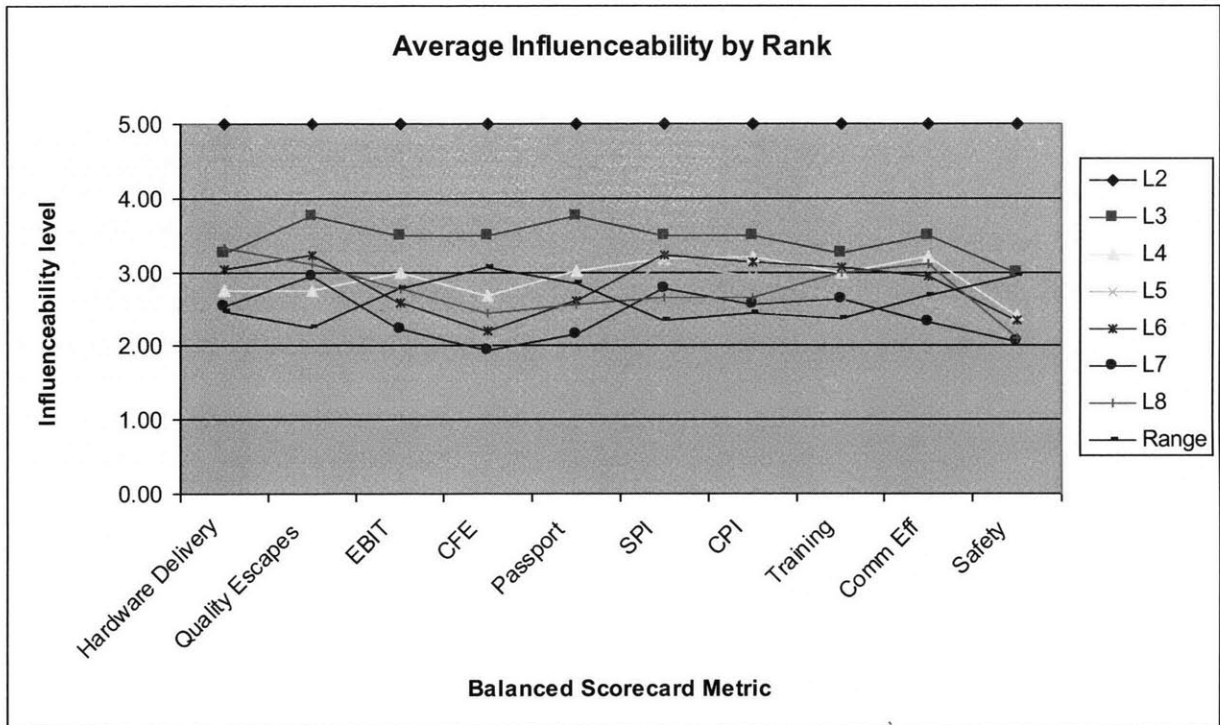
APPENDIX 2. Continued

Customer Importance



APPENDIX 2. Continued

Influenceability



APPENDIX 3. Summary of Participant Comments

Understanding (60 total)

- Many Didn't understand "TRIR/LWIR" acronym
- Many didn't understand "EBIT", though less than TRIR/LWIR.
- "Discussion surrounding TRIR/LWIR do not come up often, thus most of us don't know what the acronym stand for." – L6 Program Office
- "metrics are ok to understand; difficult to interpret our implementation/measurement..." – L6 engineer
- "The algorithm for determining metric values on the control towers is obscure. Its not that the metrics are hard to understand in themselves, its that they are at such a high level that I don't know what the metrics mean. For example, delivery performance. Does that include MAKE and BUY sides? Does that take in account late units from previous months? Its difficult to ascertain from just "Hardware Performance for March: 94%" - L7 engineer
- "Passport, SPI, CPI are difficult to understand only because the way we are measuring these items continues to change"
- "I will assume you are referring to the Business Office [Balanced Scorecards]. Communications and Employee training are two areas that do not have enough visibility into what is being measured and how. While it is nice to show EBIT, without the conservations explaining how people impact EBIT, it is just another metric" – L5 engineer
- "Items listed as "hard" to understand is because most people don't know what the definition is for each of these items. There needs to be a "definition" slide somewhere on the [Continuous Improvement] board to helps people with understanding exactly how each metric is defined." – L4 Engineering mgr.
- "What is the control tower to all levels [company] employee to understand?" – L5 Engineering
- "I dont think its particularly dificut to understand the metrics, its difficult to relate how individuals' jobs affect the metric." L7 engineer
- "Chart is too busy. There was training on it but the training took over an hour and most of us were still lost." L5 engineer
- "All represented on [Balanced Scorecard] Matrix" – L5 engineer [who obviously read the chart carefully – everything "very easy" to understand]
- "[Balanced Scorecards] vary by departments and programs in some cases - bigger drive to standardize(?)" L5 engineer
- "Most people don't even know what the accronyms are, and if they know what it stadns for they don't know what it means. Most people have no use for such a comapny wide control tower." L7 engineer
- "It would be easier if I knew what data was used for the metric." – L7 program office
- "Responses resulted from long standing [Continuous Improvement] participation." – L5 Ops [answered all "Easy"]
- "Except for the quality data..., I would not be able to explain any other category" – L7 Quality [illustrating possible silo-ing effect]
- "I don't understand exactly what Passport is measuring, I don't think it has to do with effectiveness of reviews" L5 Other

APPENDIX 3. Continued

Accuracy (33 total comments)

- Same "TRIR/LWIR" and "EBIT" questions
- "we manipulate metrics to tell the story we want told" – L5 engineer [gave low scores in general]
- "It seems that we do anything to make the metric, including changing the methodology and rounding to reach the numbers. We should be excited to see problems in [Balanced Scorecards]. They indicate an area where we can improve and engage the employees working on" – L7 engineer
- "not sure how metrics are acquired, if not using employee timesheets then accuracy is questionable" – L5 engineer [referring to metrics where this information is implied]
- "Transparency in how each item is calculated would be very useful." – L4 Program office
- "Items listed as "somewhat accurate" are due to the fact that 1) the data provided is based on a person's perception of what has or hasn't been "completed" or 2) you're counting on people to input something into a system in order for the data to be collect" - L4 engineering
- "Recommend more frequent updating" – L5 Ops [referring to monthly update period]
- "Not a good process to measure on time delivery;Not many people know how to calculate Earned Value" – L6 Program Office
- "i would imagine that all the information is accurate - reporting the false data would probably be more challenging then using the actual, regardless of the impact." – L6 engineer
- "True" Values of each Metric likely unknown to ANYONE !" – L4 Engineering [referring to use of word "true" in survey question]
- "SPI/ CPI based on Tiger read-outs; Possibly some discrepancies in measurements if tasks are re-baselined on continuous basis/ Not clear as to how Communciations Effectiveness is Measured" – L5 engineer
- "Measures that are not subjective are much more accurate" – L5 Quality
- "I believe that management is manipulating metrics in order to make the control tower look good for ACE. SPI/CPI are right on but people are clearly behind schedule and do not have adequate staffing." – L5 Program office
- "CPI accuracy can be misleading as customer approves EAC growth (authorizes customer funded work) without budget when work is clearly out of scope." – L4 Program Office
- "Not convinced good info is available from the multiple training databases/systems." – L5 Engineer [referring to Employee Training metric]
- "Need quality measure for Passport" – L4 engineering
- "Who really know the EBIT as Finance hides and moves numbers around all the time... LOL!!!" – L5 Ops
- "I honestly don't deal with the [Balanced Scorecard] closely enough to comment on level of accuracy" – L6 Engineer

APPENDIX 3. Continued

Internal Importance (23 total)

- More "TRIR/LWIR"
 - "if trir / lwir were so important, we'd know what it is" – L5 Engineer
- "If we could deliver everything on time, on budget, and with high quality, we would be the world leader in aerospace" – L7 engineer quoting a VP.
- "Not sure what passport is measuring. Conducting passports important. If it is measure of conducting or not, timely or not, it would be important" – L3 Quality [apparently saying it's a good measure if it measures that we did it, and did it on time].
- "If you measure HW delivery, you need to measure inventory levels, too. On-time HW delivery can come at the expense of high inventory levels." – L5 engineer
- "Employee training is dependant on how much "free time" people have to take training and is there enough "overhead funding" to support such training if everyone decided to make it a priority each month or quarter to take training classes" – L4 Engineering
- "Recommend date and time stamps for all portions to confirm how recent is the information" – L5 Ops [possibly suggesting importance changes with the relative metric levels over time]
- "Does it important to everyone? or juct for high level person?" – L5 engineer
- "EBIT may not be that important to [this business unit] because most money is made in aftermarket for work done here" – L6 Program Office
- "Understanding of specific metrics would greatly benefit the importance factor for business strategies." – L5 engineer [suggesting that understanding and importance are not independent of one another]
- "All extremely important measures. Understanding why and how we gather data. What does it mean to the buisness and how can I have a positive impact on it." – L7 engineer
- "Although Communications is important, the way we measure it is not sufficient" – L4 Engineering [referring to Communication Effectiveness metric]

APPENDIX 3. Continued

Customer Importance (23 total)

- More "TWIR/LWIR"
- "The metric's importance to the customer does not measure the organizational effectiveness as a result of the metric. Our CPI may not matter to a customer if it is company funded engineering, unless it causes us to stop work on a program. THAT result is not in the metric, only cost performance is." L2 Engineering
- "Communication Effectiveness as measured for internal flow of information is not as important to the customer, as compared to the communications between business unit and customer. Not sure how the second is measured in the control tower except for MFA." L4 Program Office
- "I am assuming you mean EXTERNAL CUSTOMER" – L4 Program Office [referring to context in which metrics were rated]
- "The customer wants a flawless product on-time, on-schedule, and within cost. If you do this, they don't care how you got there." – L5 Engineering
- "Assumption made here is that "customer" refers to both internal and external customers." - L4 Engineering
- "Lack of CFE funds can have a significant negative impact on customers" – L4 Program Office [referring to rating for CFE of 2]
- "Although I would not expect our customers to find the other metrics important to their "day to day" operations, I would expect that they would be concerned with the impact these metrics have on their vendors solvency." – L6 engineer
- "I am assuming you mean EXTERNAL customer. INTERNAL customers (Management) would have a different viewpoint." – L5 Quality
- "Clarification on Communication Effectiveness: External Communication to Customer" – L5 engineering [clarifying perspective on Comm Eff metric rating of 5]
- "CPI would be a function of Contract Type FFP Low, CPF High" – L5 engineer [pointing out distinction between internally vs externally funded engineering effort]
- "Responses based on FFP programs where customer does not care about our internal costs." – L6 engineer
- "Customer is concerned with CFE only to the extent it may influence program investment" – L4 Engineering

APPENDIX 3. Continued

Influenceability (18 total)

- “All of us have the ability to highly influence all the metrics. When we all realize that our performance will dramatically improve.” L2 Engineering
- More TRIR/LWIR comments not understanding acronyms
- “we spend too much time working metrics vs completing the work to achieve the actual milestone.” - L5 Engineering
- “Most of these items are accomplished as a team, not individually.” L5 Engineering
- “I have too much work to do to spend time studying the [Balanced Scorecard] except before [a Continuous Improvement] audit.” L4 engineering
- “Does everyone understand what it [Balanced Scorecard]?” L5 Engineer (this guy was a gem...)
- “Most metrics are unachievable due to lack of funding, training and time. [Other] customers don't get delivery priority; What company has budget for CFE is what we get period; many metrics reflect supporting groups (manufacturing, purchasing, etc) outside our control.” L6 Program Office [suggesting some customers get priority over others, influencing metrics]
- “Little influence when training budgets are restricted” – L4 Program office [maybe referring to low rating for Employee Training metric]
- “[Balanced Scorecard] metrics are provided to us by sr. management” – L7 program office [maybe misunderstanding metrics are measurements as well as goals??]
- “Q5 is not clear to me - influence to change the category & how it is measured, or to impact the metric through my personal work performance?” – L5 Other [referring to wording of question; intent of question was the 2nd description]

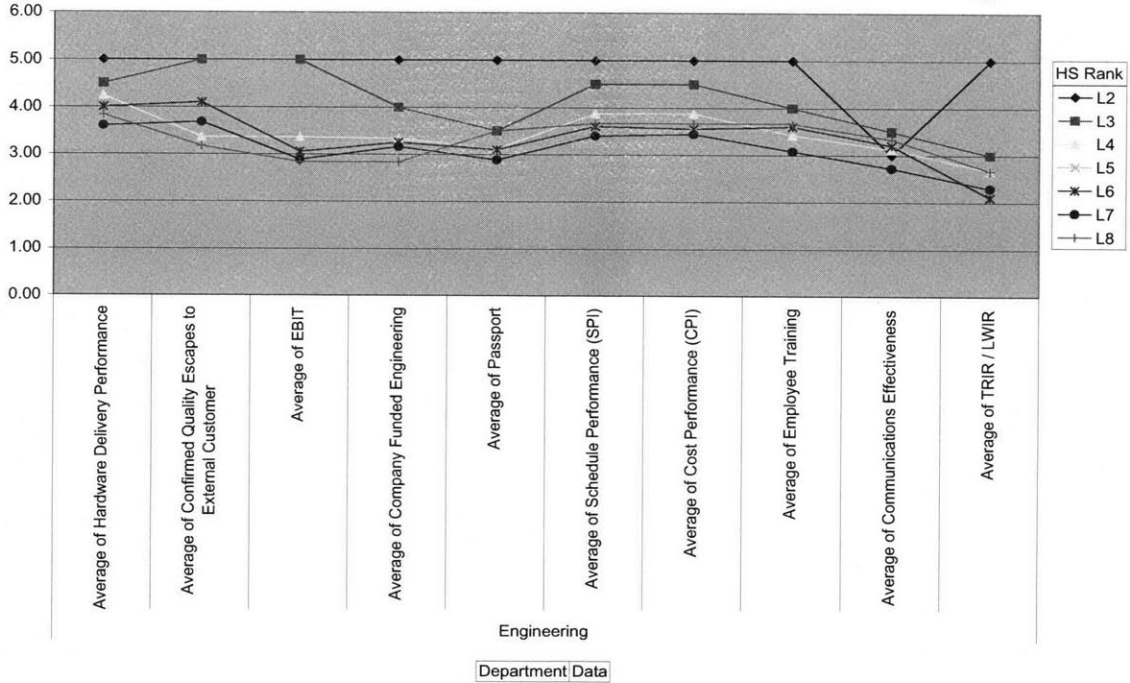
APPENDIX 4. The “Missing Metric” Comments

- “None” (160 out of 238)
 - Some added comments: “Too many already; doesn’t help me much anyway; this may change..”
- MFA or Customer Satisfaction – 8
- Employee Satisfaction about 10
- “Metrics will evolve based on business conditions” – L2 engineering
- Efficiency of some form – about 5
- “Common Sense” – 1
- COPQ – about 5
- Accounts Receivable – 1
- New business gained
- Engineering Escapes – L3 Engineering
- Inventory – 2-3
- “management Effectiveness” – 1 or 2
- Linkage of individual goals to Control Tower – 1
- Quality of Requirements
- Product Safety
- Overtime hours
- Technology advances
- Internal turnbacks
- Production Test Yield
- Warranty costs versus planned
- Cost Reduction actuals vs targets
- Innovation measure – new patents or new designs
- Attrition – internal and external
- Benchmarks to other companies

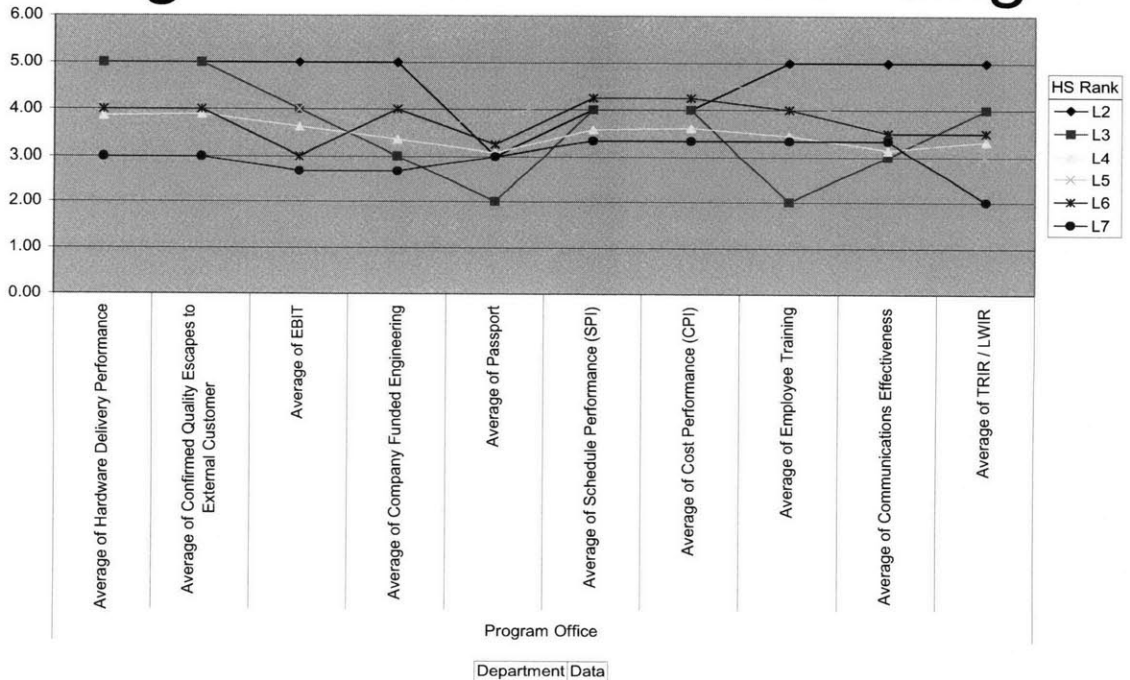
APPENDIX 5. Engineering vs Program Office Attribute Comparison

Understanding

Engineering Understanding



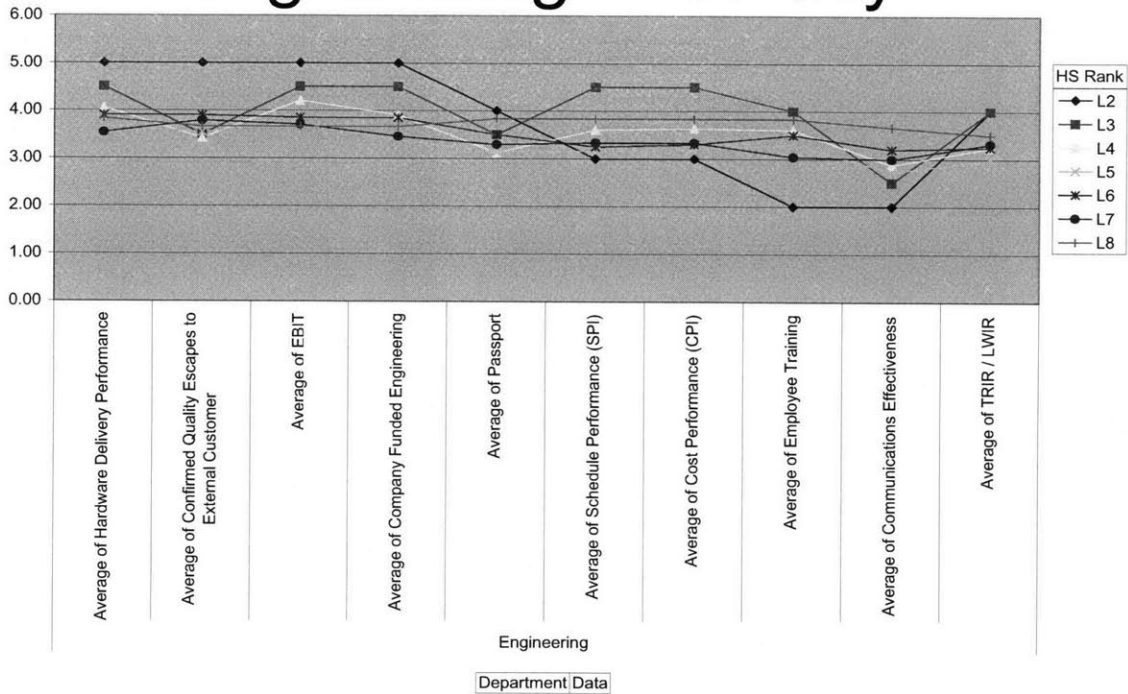
Program Office Understanding



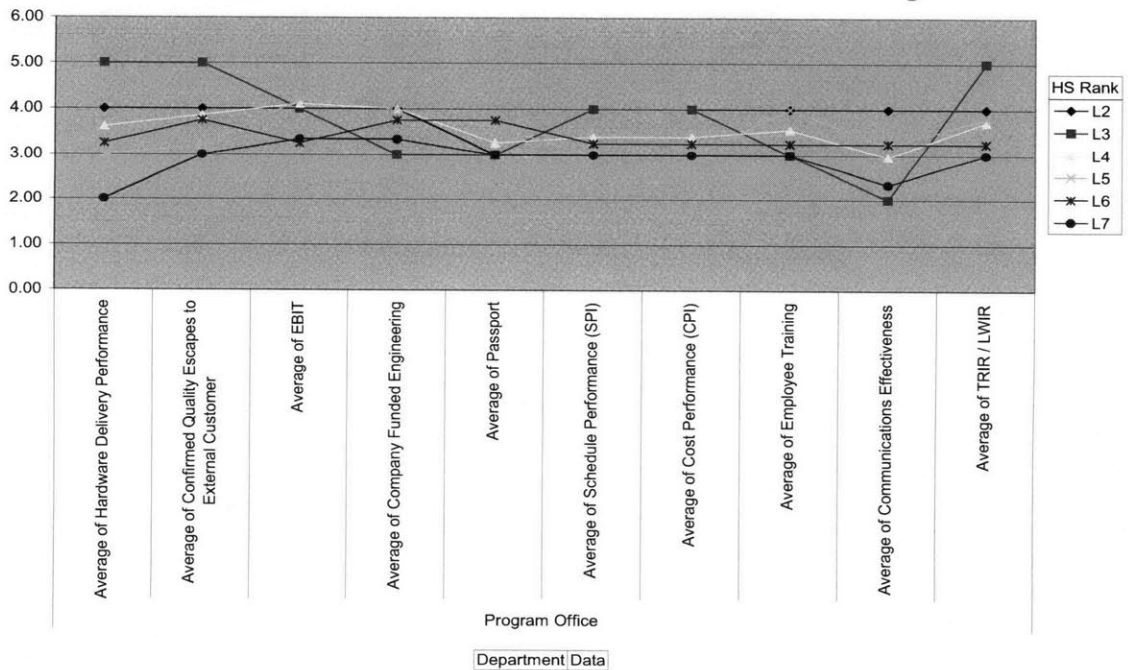
APPENDIX 5. Continued

Accuracy

Engineering Accuracy



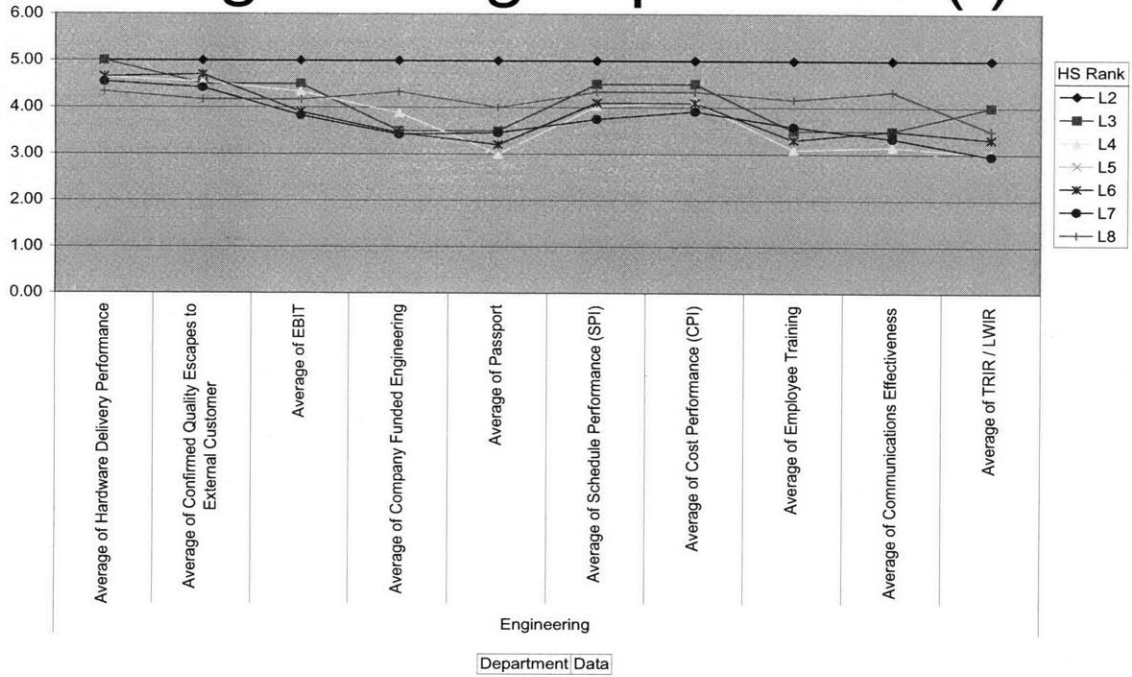
Program Office Accuracy



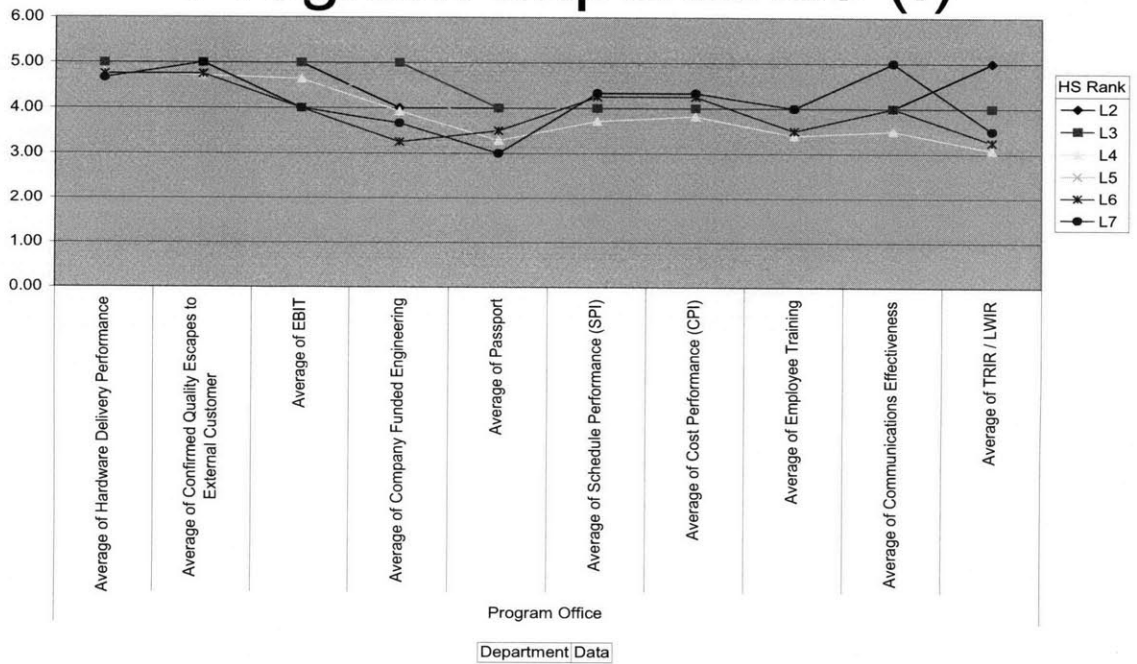
APPENDIX 5. Continued

Internal Importance

Engineering Importance (I)



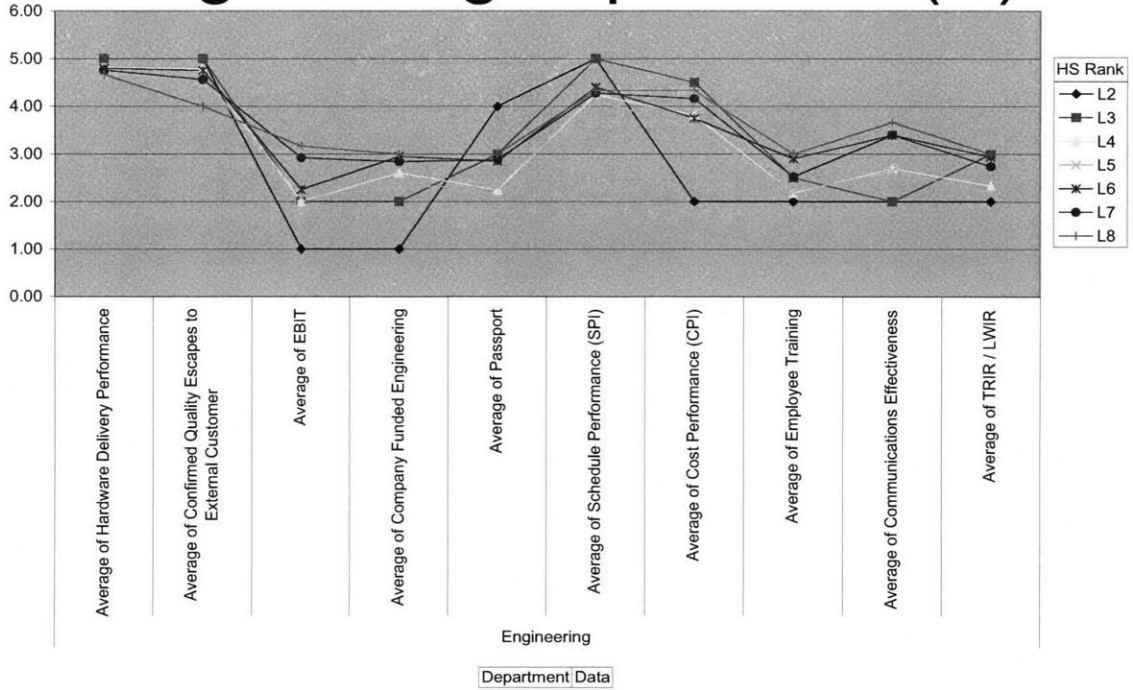
Program Importance (I)



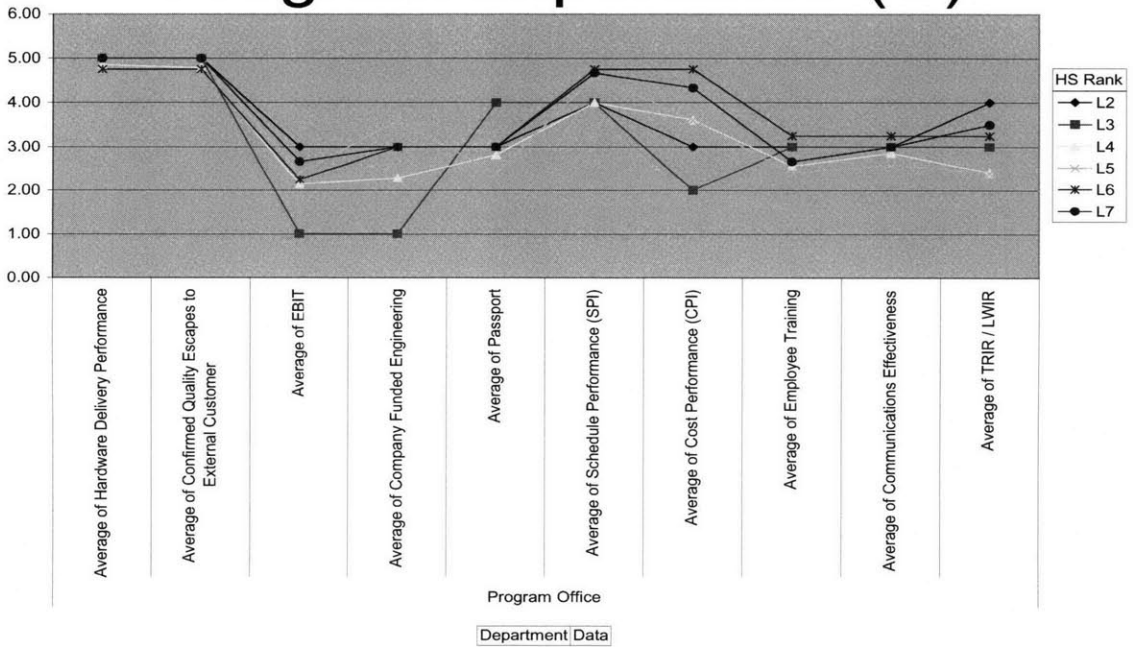
APPENDIX 5. Continued

Customer Importance

Engineering Importance (C)



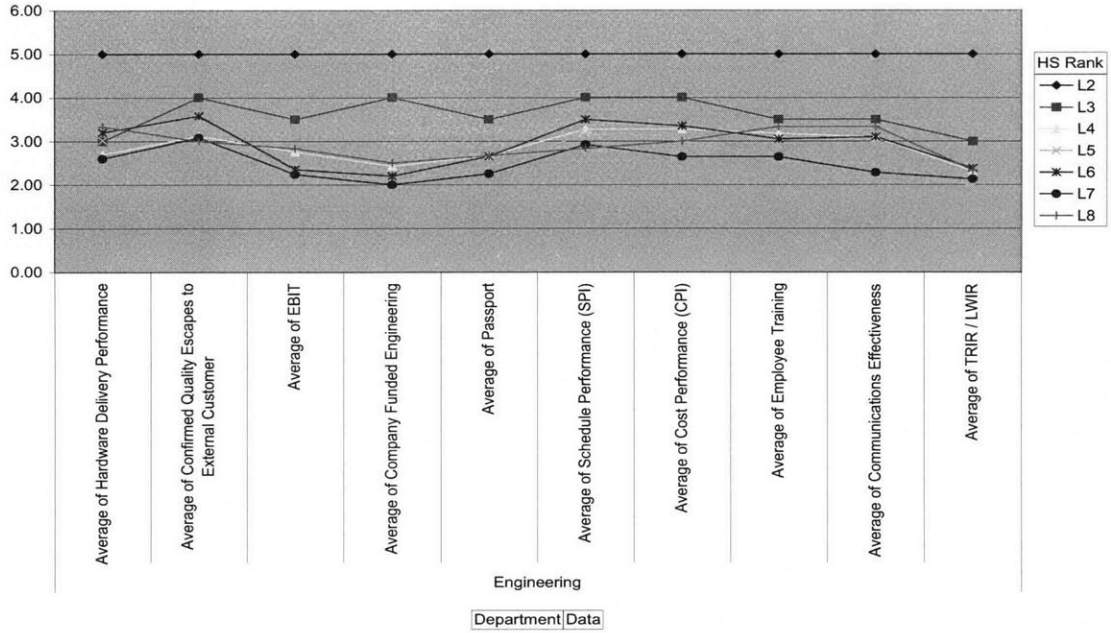
Program Importance (C)



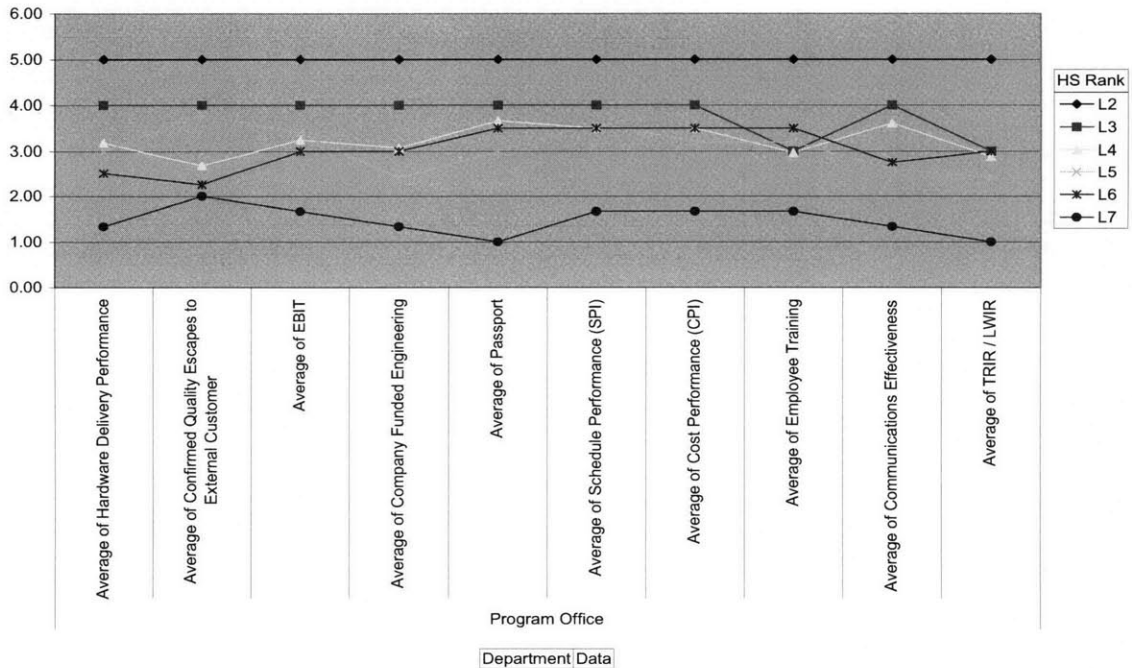
APPENDIX 5. Continued

Influenceability

Engineering Influenceability

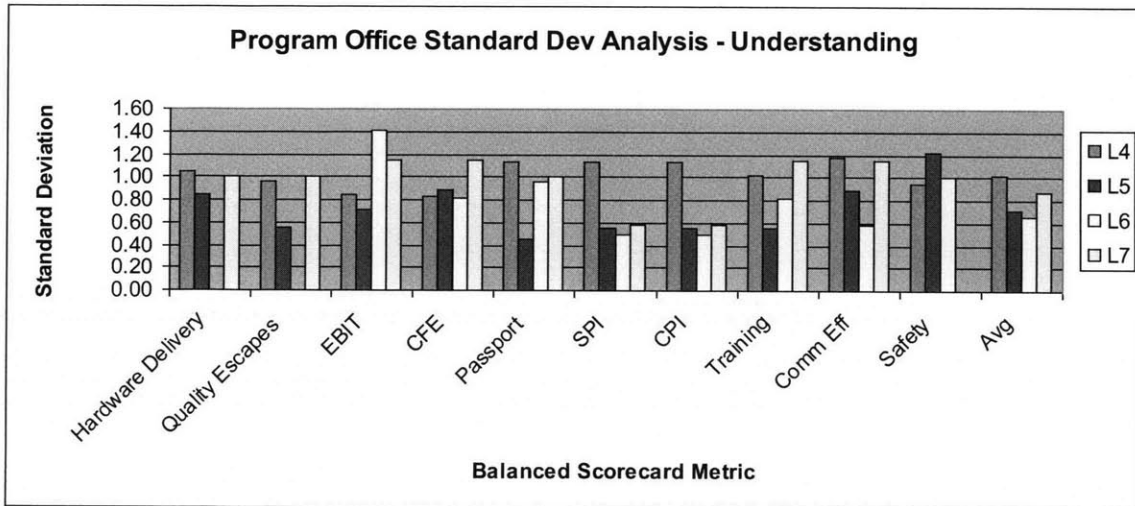
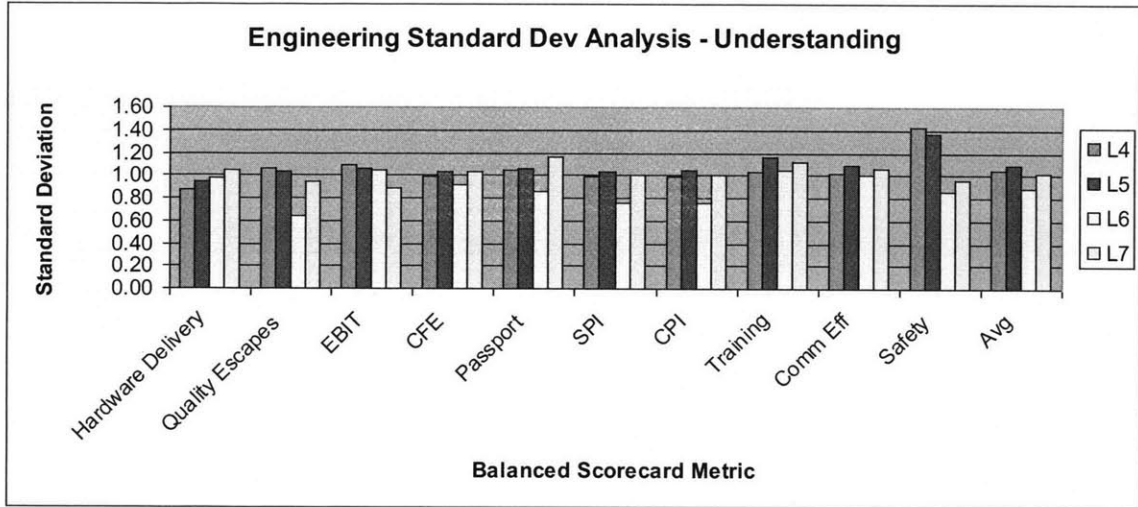


Program Office Influenceability



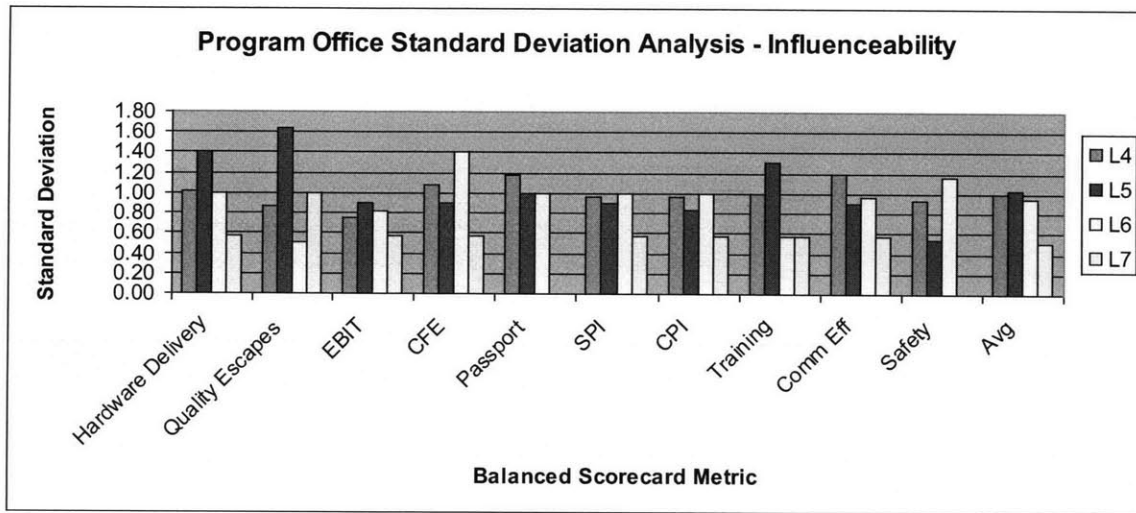
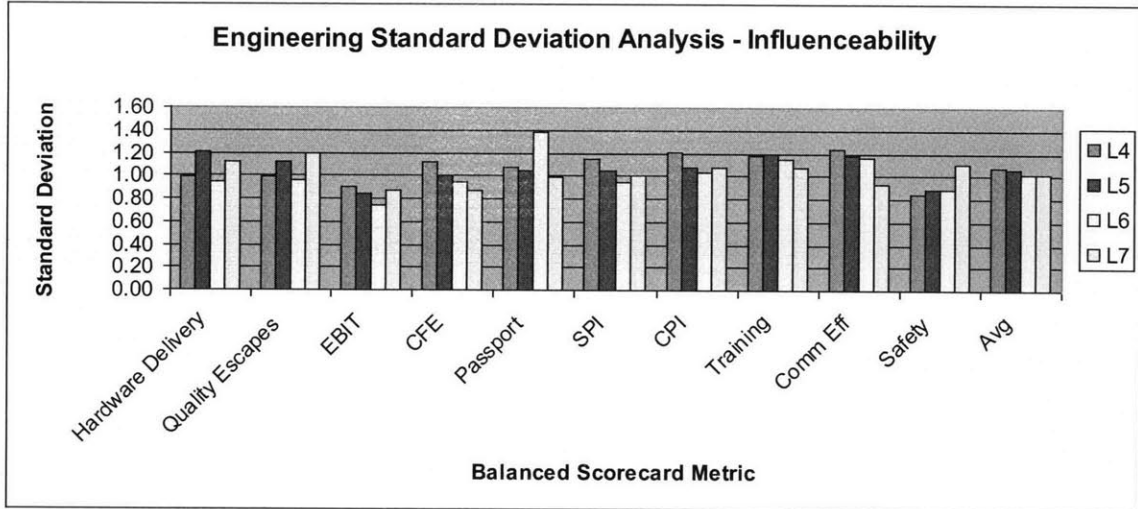
APPENDIX 6. Engineering vs Program Office Variance Comparisons

Understanding



APPENDIX 6. Continued

Influenceability



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